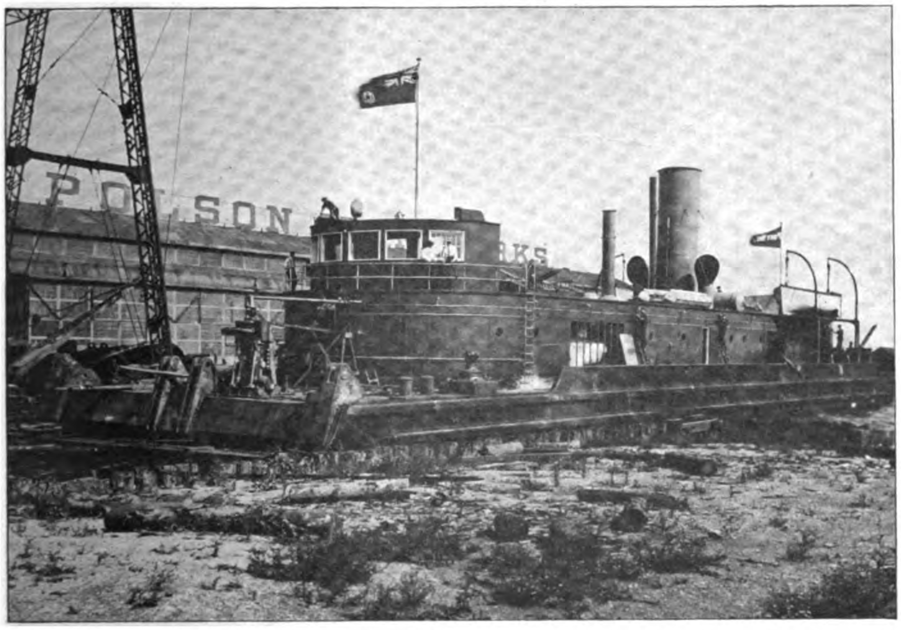
THE MARINE REVIEW

VOL. 43 CLEVELAND SEPTEMBER, 1913 NEW YORK No. 9

Suction Dredge Port Nelson

Description of an Hydraulic Dredge Which the Polson Iron Works Built in 100 Working Days

THE Polson Iron Works, Toronto, made quite a record for itself in the construction of the 24-in. suction dredge Port Nelson for the Dominion government. The contract for the dredge was let early in April last and the work was completed in 100 working days. She was inspected at the plant of the Polson Iron Works on Aug. 6 prior to her trip to Hudson bay. The dredge is intended for service in Hudson bay at the terminus of the railway from Pas, Man.



SUCTION DREDGE PORT NELSON

A plan and elevation of the dredge are given herewith. It is the second largest dredge ever built in Canada, being 180 x 43 ft., with a moulded depth of 11 ft. and a draught of 6½ ft. Completely equipped, it will weigh 1,200 tons. The dredge is a double-decked structure, steel throughout, and fitted with five bulkheads, dividing it into six watertight compartments. The 24-in. suction pump is located in the forward end of the hold, directly connected with a 14 by 22 by 36 by 21-in. triple-expansion engine, obtaining steam from two 13 by 12-ft. Scotch boilers, also located in the hold, to the rear of the engines.

At the rear of the dredge is the suction pipe and cutter head, on an arm pivoted to the rear end of the deck and supported at the outer end by cables from shear legs, one on each side of the deck, these latter being braced by cables from near the front of the boat. The cutter arm will dredge to a depth of 48 ft. The cutter at the outer end of the suction pipe arm is a steel casting with six attached manganese steel blades. Two sizes of cutters are to be employed, 4 ft. for hard material, and 5 ft. for soft material, both of the same general construction. These are to be driven through a shaft along the cutter and suction arm, and a system of bevel gears, by double 12 by 12-in. vertical engines on the rear end of the deck. The suction pipe of 26 in. seamless tubing, ½ in. thick, connects at the boat, through a ball connection, to a pipe running back to the centrifugal pump, which will discharge through a similar pipe running along the side of the boat to the front, where connection will be made with piping, 3,000 ft. of which is to be supplied. This latter is to be of the floating type, carried on each side by floating cylinders. When working with a short length of discharge pipe, the capacity will be 20 cu. yds. of solids a minute, or 1,200 cu. yds. an hour. When using the full length of discharge pipe, that is, 3,000 ft., the discharge will be reduced to 800 cu. yds. an hour. The design of the dredge is such that a side connection from the dredge near the pump can be easily arranged.

The operation of the dredge will be out of the ordinary, it not being of the stern pivot type. Two three-drum steam winches will be located, one at the forward end of the engine room on the main deck, the other below deck in the machine shop aft, and by means of anchors located some distance each side of the vessel at both front and stern, the dredge will be moved from side to side bodily, the dredge end of the discharge pipe moving with it. The cutter and suction arm at the front will be raised and lowered by a winch engine in the center of the vessel. All the control of the suction, cutter and winch machinery will be from a central point at the rear in an operating room, on the upper deck.

An 8-in. centrifugal bilge pump will be located on deck on the starboard side of the dredge, connected with all the bulkheads. This pump will be

steam-driven, obtaining the steam from a 48-in. locomotive boiler in front of it on the deck. This latter will also be used as a source of auxiliary steam, for use in heating the vessel when it is laid up, and the main boilers are out of commission, also for auxiliary purposes.

There will be a 10-k. w. steam-driven generating set in the engine room for the supply of electrical power.' This will be used for lighting the ship and for search lights above the deck, front and rear.

A most important feature of the dredge is a complete machine shop, equipped with lathes, planer, drills, etc., in a room in the hold at the stern. In addition, there will be installed a compressed air unit with a supply of air tools, and a small brass furnace for the production of small brass castings. This will make the dredge self-contained in the event of break-downs far away from supplies.

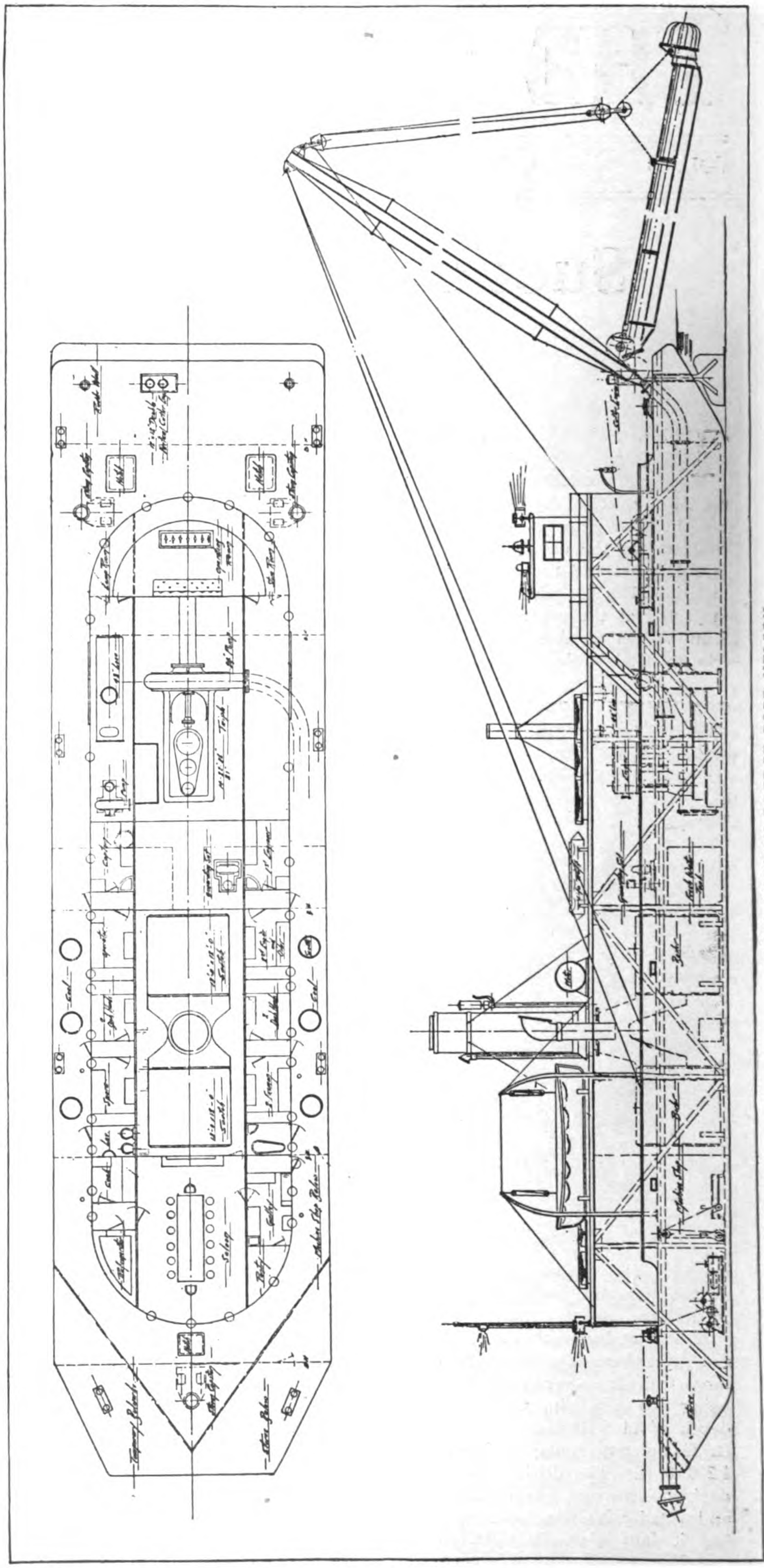
Both sides of the main deck at the front of the engine room are divided off into cabins for the officers and crew, and the central part of the main deck at the front forms a saloon. The dredge carries a crew of 35 men.

The dredge, while operating for the most part in fresh water, has been given salt water equipment throughout, including copper piping. There will be a fresh water tank of 80 tons capacity. The coal capacity will be 250 tons.

The dredge is to make the trip from Toronto to Hudson bay by way of the St. Lawrence river, being of a suitable size to pass through the locks, and around the Labrador coast, being towed all the way. Temporary rudders on each side of the stern will be added for the trip. The dredge is provided with 600 ft. of 1½-in. stud link chain with a 3-ton anchor. A sea anchor has also been installed in case it is necessary for the tugs to cast the dredge adrift at sea.

The dredge was built to the designs of Wm. Newman, works manager. The motive power and auxiliary machinery were designed by J. Sharp, chief engineer. The short time allowed for the completion of the work by the company has necessitated carrying it on 24 hours a day. The cost of the dredge approximated $270,000.

During the time in which the dredge was constructed the Polson Iron Works have also built a stern wheel tow-boat of the shallow draught type, for use on the river at Port Nelson, for the department of railways and canals. The principal dimensions of this tow boat are: Length over all, 117 ft.; length b. p., 104 ft.; breadth,



STEEL SUCTION DREDGE PORT NELSON

18 ft.; depth moulded, 4 ft.; draught complete, 2 ft.

The engines are double 12 in. x 48 in. simplex non-condensing high pressure. The stern wheel is 15 ft. dia. and 18 ft. long. The boiler is of the locomotive type, 56 in. x 15 ft. Fresh water tanks of 2,000 gallons capacity are fitted. The boat will be lighted by electricity and heated by steam throughout.

This boat was built in two weeks, knocked down and stowed in the hold of dredge Port Nelson, to be re-erected on its arrival at destination. A chief engineer and a shipbuilder are supplied by the firm to superintend the work of re-erection.

SUCTION DREDGE PORT NELSON ON THE WAYS

Powerful Wireless Station at Panama

Construction is to begin shortly on the large naval radio station at Caimito, Canal Zone, to be known as the Darien Radio Station. This is to be a 100-kilowatt plant, of the same power as the Arlington station, near Washington. In the size of its towers it will exceed the latter; all of the three masts will be 600 ft. high, whereas at Arlington one of the towers is 600 ft. in height, and two are 450 ft. high. The bases of the towers will be about 180 ft. above sea level, and they will be arranged in a triangle, approximately 900 ft. on a side. The sending and receiving radius will be nominally 3,000 miles, so that communication may be held direct with the Arlington station, instead of by way of Key West, as at present. The station will be able to "talk" to San Francisco, 2,785 miles away, by air line.

The present stations at Colon and Balboa will be continued in use, to handle messages for ships using the canal, and the Caimito station will be used exclusively for official business of the government, principally as a relay station for communicating with ships of the navy in southern waters. It will be able to send messages as far as Valvidia, 421 miles south of Valparaiso; and, on the Atlantic side of South America, as far down as Buenos Aires. It could reach a vessel anywhere along the eastern coast of the United States, or midway between New York and Gibraltar, on the Mediterranean route; in approximately east and west lines, it could communicate with the island of St. Vincent, 500 miles west of Africa.

In sending, the station will use the Poulsen wireless apparatus, employing sustained oscillations, considered an improvement on the spark method. Situated between the canal and the Panama railroad, its antenna will span an arm of Gatun Lake. The water will afford good electrical grounding, and furnish the waves a good "grip" in starting. The Federal Co., which is operating stations along the west coast of North America, has the contract for furnishing the apparatus.

The navy department has authorized the Isthmian Canal Commission to construct the following buildings, at estimated costs as shown: Power house, $7,800; operating buildings, $4,600; quarters for operators, $7,600; total, $20,000. The Penn Bridge Co. is the contractor for the towers; the concrete footings for them will be installed by the Canal Commission. Forces of the quartermaster's department will have sharge of the work to be done by the Commission. Lieut. R. S. Crenshaw, U. S. Navy, is stationed on the Isthmus in charge of radio stations.

The Hamburg-American Steamship Co. announces that beginning Sept. 16 it will inaugurate a regular fortnightly steerage service between Hamburg and Baltimore. This is the outcome of a recent dispute with the North German Lloyd, which hitherto has had a monopoly of the immigrant transportation into Baltimore.

HOISTING MACHINERY ABOARD SUCTION DREDGE PORT NELSON

Producer Gas Engines

The Wolverine Motor Works is Developing a Type of Engine Which Does Very Well With Producer Gas—Some of the Results

THE Wolverine Motor Works, Bridgeport, Conn., manufacturers of marine gasoline and kerosene engines, are developing a type of engine which works very well with producer gas. They have met with considerable favor abroad and are extensively employed on the rivers and canals of Europe. The company recently received a letter from an American traveling abroad detailing his observations on the subject. He said:

"The first sight to greet my eye in crossing from Dover to Ostend, was the 66 ft. yacht Liline on its way to Folkestone, England, in the kind of sea that is characteristic of the English channel. On inquiring as to the motive power, was very much pleased to learn that the boat was fitted with an American-made motor (36 H. P. Wolverine). Ten days later, I saw the Liline on the River Rhine, near Wiesbaden, making the passage through what is known as Binger Loch, one of the most rapid parts of the Rhine, where only power boats equipped with excessive power are supposed to be able to navigate the current. A few days later, on my return to Belgium, I received a message from the owner, Mr. Kirk, whose residence is at Folkestone, England, congratulating us as they had successfully navigated Binger Loch."

FIG. 1—THE LILINE IN THE RIVER SHELDE

Fig. 1 shows the Liline as she appeared in the river Schelde, and Fig. 2 shows her at Folkestone, after having made the trip across the English channel under the most unfavorable weather conditions.

Continuing, the writer says that what interested him most, however, was the heavy work type of boats of which he was fortunate enough to secure a few pictures. Fig. 3 shows the tug Wolverine IV equipped with an American-made producer and 75

FIG. 2—THE LILINE IN FOLKSTONE HARBOR

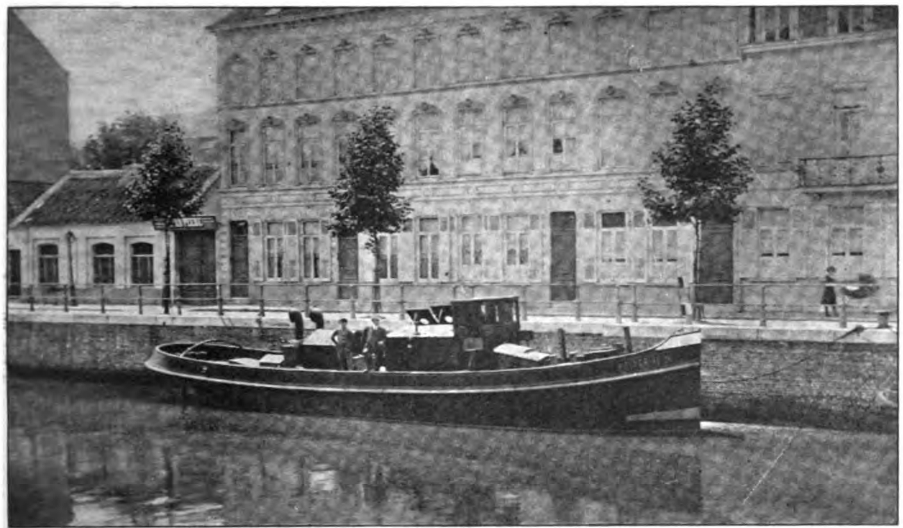


FIG. 3—TUG WOLVERINE IV EQUIPPED WITH GAS PRODUCER AND WOLVERINE ENGINE

H. P. Wolverine engine. This boat was built at Ghent, Belgium, and is of steel. It has been in constant operation for the past four years, doing heavy towing. Fig. 4 shows a laden barge passing through the city of Ghent. This barge, capacity 2,000 tons, is being towed by the tug Wolverine IV, a part of which only is shown.

He adds: "The tug boat proposition is very much in evidence on the Continent and practically all of the later installations in France, Belgium, Holland and some in England, are in connection with producer gas on account of its extreme economy and absolute reliability. I was told by a number of skippers who are using producer gas that they could never be induced to go back to oil or steam. The boats are handled better than on any other fuel known.

"The Marie, Fig. 5, and the Ville de Bruxelles (Fig. 6) are characteristic of this class of boats. The Marie was taken after the boat had passed through the locks, and having only a small cargo, while the Ville de Bruxelles was taken when the boat had just arrived from Brussels with a cargo of 180 tons. This vessel is packed full in the hold and some cargo still left on deck. When she arrived, the cargo was piled on deck at least 6 ft. high, pushing the boat down into the water so that she had at least 6 ft. of draught. This boat, as well as her sister ship, Ville de Gand, built on the same lines, are running on schedule time between Ghent and Brussels, making about two trips a week, in competition with steam, man power and the railway.

"An outfit carrying 500 tons of coal has lately been put into commission running from Belgium into Germany. It is fitted with a 75 H. P. producer plant and 75 H. P. Wolverine engine, and has entered into a contract to carry coal from the German mines to different parts of Belgium for five years against the same kind of competition.

"It is very gratifying to know that American-made products are being recognized in Europe as among the very best, although by no means the cheapest that can be obtained.

Consumption of Fuel

"The consumption of fuel on producer gas has been reduced to such a low quantity that one can say it is almost nothing as compared with the former cost of operation on oil. Careful records kept in this connection show that the cost for operating a 36 H. P. Wolverine engine on producer gas for 12 hours was $0.84 as against $5.00 formerly spent for heavy gasoline. In fact, the cost per horsepower hour has been reduced to about 1/5 of a cent.

"Another thing in favor of this class of power is the number of the crew required. There is of course a skipper, or as we call him, the captain, who navigates the boat, and a boy about 14 years old whose business it is to oil the engine and about once an hour put from 25 to 50 lbs. of coal into the producer, the plant requiring no other attention. This statement is so unusual that to the

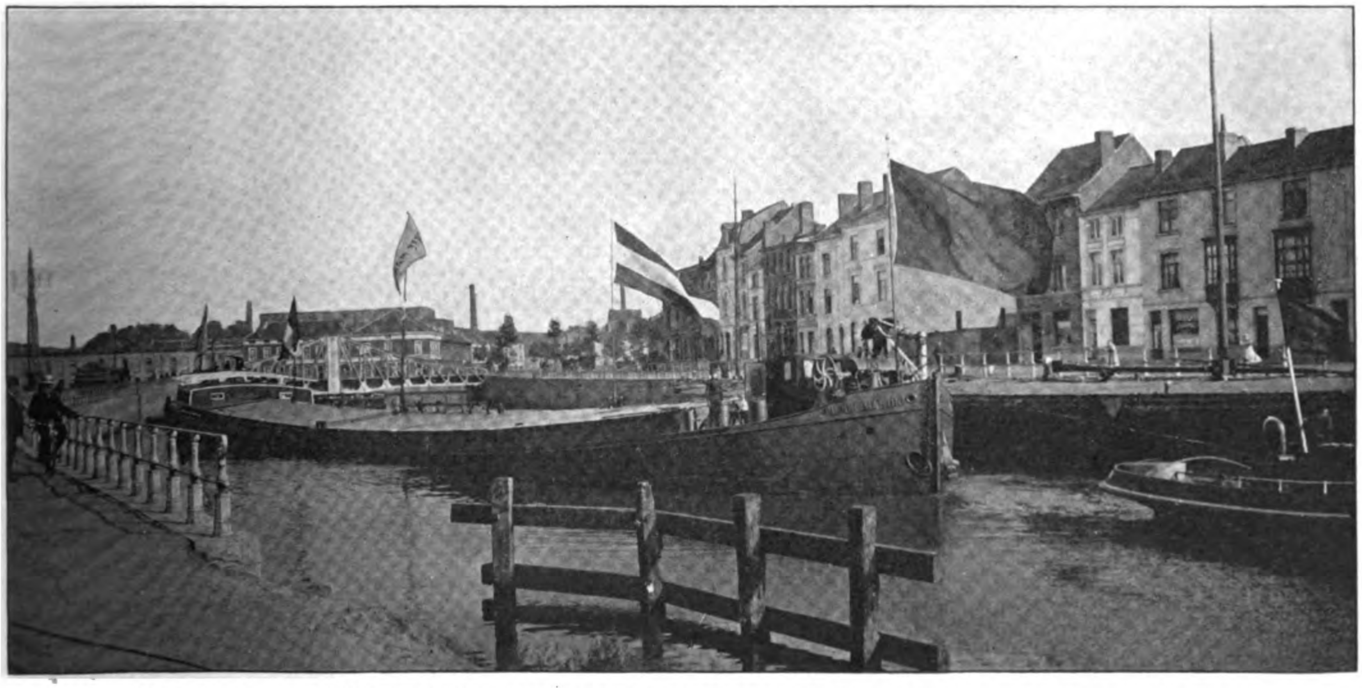


FIG. 4—LADEN BARGE PASSING THROUGH THE CITY OF GHENT TOWED BY TUG WOLVERINE IV

ordinary individual who has not acually seen it with his own eyes, it seems unbelievable."

Concerning the gas producer proposition the company says:

"It is more recently that the producer proposition has become of interest in our own country on account of the high price of gasoline and other oils. However, the Wolverine engine has been installed in a number of outfits with most excellent results. With one outfit in Florida, we were able with a producer plant to carry a ton of freight 160 miles at a cost for fuel of 3 cents.

Doing Fine Work

"Some recent installations in Delaware and North Carolina are doing very fine work in the menhaden fishing industry. The M. M. Marks, an 85-ft. schooner fitted with 75 H. P. Wolverine engine and producer, on her first trip out brought back 125,000 lbs. of fish. The cost for fuel was equivalent to gasoline at 2 cents a gallon. The handling of the boat is better than can be accomplished with the very best gasoline engine that was ever built.

"Another installation was made at Lewes, Del. The first trip with a new engineer, practically inexperienced, was from Lewes to New York City, about 150 miles and return, without a hitch or difficulty of any kind whatever.

"A third installation at Smyrna, Del., will be completed shortly and we expect equally as good results.

FIG. 5—FREIGHT BOAT MARIE WITH PRODUCER GAS INSTALLATION

"See August MARINE REVIEW.

"In fact, in all the installations we have made in different parts of the world, using different kinds of coal—Welsh anthracite, Belgian anthracite, anthracite found in our own country, and certain kinds of coal found in France, we have had uniformly the same results, absolute and positive success.

"The results we are obtaining today with our engines in connection with producers have not been results of a few hours study. The high price of oil, we have anticipated for a number of years, and we have had an experimental engine and producer plant in our shops, using it for our power plant for the last six years constantly, observing it and making a long series of experiments until we have accomplished what we have. We are today in a position to guarantee that with a proper producer installation, the Wolverine engine will work as good or better than any gasoline engine ever built.

"In fact, we have the proposition down to so fine a point, that we are now rigging up al of our engines

FIG. 6—FREIGHT BOAT VILLE DE BRUXELLES, WITH 36-H. P. WOLVERINE ENGINE AND GAS PRODUCER

and in a short time will be in a position to run out all of our engines on the test block with producer gas instead of gasoline giving them only the final test on gasoline or oil where these fuels are to be used. This is an item of economy as the cost will be only about 1/5 as much for fuel as the old way of testing them out. We are able to do this with the Wolverine engine since very few changes are necessary to convert an engine from gasoline to the producer type.

"We have, at the present time, a contract for installation of three 36-H. P. engines in France. This is the beginning of a fleet of no mean dimensions which it is proposed by the company to be used in the French canals where the present means of locomotion are still very crude, horses being used and in some instances man power to pull the boats through the canals, similar to what was formerly done in the New York canals. However, since the American engine has made its appearance in the canals and rivers on the Continent, the old means of locomotion are very largely being changed to producer gas outfits. It is practically impossible to dispose of a gasoline engine at any price, except for very small units where the cost of fuel does not cut much of any figure, as in many places gasoline is as high as 50 cents a gallon and not very good quality at that.

"The kerosene engine, for small units, is very extensively used in all European countries and in this line the Wolverine has been the leader for a number of years, and we have lately perfected a system with which we hope to be in a position to guarantee consumption of kerosene to be no greater in quantity than the very best gasoline and to be able to handle the engine equally as well, being as flexible as the best constructed 4-cycle engine that uses gasoline, with no knocks, which, up to the present time, to our knowledge, has not been accomplished by any other concern. This latter device, however, is not yet ready to be put onto the market.

Demand for Larger Units

"The demand for larger units to operate on producer gas has made it necessary for us to build larger units of engines than we had ever anticipated building. Our new engine, to be built strictly on Wolverine lines, with 6 cylinders, we expect will develop something over 200 H. P. This we hope to have ready to put onto the market the early part of 1914. The next unit, which is now being designed, will run about 350 H. P. and both these engines will be built with a view to operating on producer gas.

"At the present time, we do not advise producer gas for installation in an outfit smaller than a boat which would require at least 36 H. P. The system is practical, as far as the producer proposition is concerned, on any size engine, but on account of the extra room required for the producer plant, it is not practical to install it in a small boat. The extra cost of the producer on small units is also an item to be considered.

"A producer plant requires almost no attention and the consumption of fuel while the boat is standing and not in operation is very small indeed. It is not necessary to build a new fire if a small quantity of coal is consumed while not in operation. We have a producer in our shop at present in which the fire has not been out since last December, and during this time, the producer has probably not been in actual use for more than two or three weeks at the outside.

Ease of Operation

"One of the principal difficulties we have had in operating a producer plant is the idea people have that they are running the same kind of an engine as a steam engine, one that needs constant attention, when the opposite is the case. We went through this same experience some years ago with the gas engine, teaching the engineer to let the engine alone. The same applies to producer gas.

"On an ordinary run, if the producer is properly constructed, the only attention required is cleaning out the ashes once or at most twice a day, and putting into the producer every hour or two, depending upon the work the engine is doing, 25 to 50 lbs. of coal. Then the producer can be closed up and left alone. This we find is the most difficult thing to teach users of this power. When the engine does an immense amount of work, the idea seems to be that an immense amount of firing must be maintained which, as above stated, is absolutely wrong.

"The general impression seems to be that any kind of a producer and any kind of an engine will work equally as successfully on producer gas as any other. This is a great mistake. A marine producer and a marine engine require flexibility, slow speed, high speed, and all intermediate speeds, while with the ordinary stationary type, the power is absolutely steady, running from morning until night.

"The boats above referred to, particularly those used in Europe, are handled absolutely from the pilot house and the operator must have absolute control of them. In one city on the Continent, there are some fifteen Wolverine outfits ranging in size from 36 to 75 H. P. There are 125 swing bridges crossing the canal and five locks before boats can get out into the river. It frequently takes an entire day to pass through the city on account of the delays in opening bridges and passing through the locks. You can realize that with a barge carrying 150 to 1,000 tons or more of freight, a skipper must be able to have absolute control of his machinery, which must not fail, as running into a swing bridge or through a lock because his engine failed to work would be a serious matter.

"It is our impression that where such results can be obtained and have been for the last four or five years, we need not hesitate to guarantee any proper installation for any kind of marine service on producer gas."

An Extraordinary Story

A Calcutta daily paper is responsible for an extraordinary story told to its representative by Capt. Burn, of the oil steamer Saranac, belonging to the Tank Storage & Carriage Co. She was laden with 6,300 tons of oil from New York for Calcutta. On May 28, when 7 miles from Point de Galle, Ceylon, and 3 miles out from shore, she struck an uncharted rock three times, and it was found that two of the tanks in the middle of the ship were letting in water. Water came in and lifted the oil to the top of the tank, and there it stopped. And in this condition the vessel was navigated up to Calcutta, a journey which took five days.

When the cargo of oil had been pumped out the vessel went into dry dock, and it was only then that the extent of the damage was discovered. Fore and aft were two huge rents in the plates, many of which had been started, and in the middle of the hull was a gash 20 ft. long and 1 in. wide, while here and there were huge dents big enough for a man to put his head through. Any ordinary steamer so damaged would have gone down in a very short while, but in the case of the Saranac, the oil kept the water out, and according to the captain, the vessel floated almost as well as though nothing had happened.

D. C. Reid, No. 18 Broadway, New York, American representative of Swan, Hunter & Wigham Richardson, Newcastle-on-Tyne, has sailed for Scotland on a brief vacation.

Electrically-Driven Ship

Complete Description of the New Vessel Which the Montreal Transportation Co. Will Put on Its Service

IN its October issue THE MARINE REVIEW gave a brief description of the Tynemount, building at the yard of Swan, Hunter & Wigham Richardson, Newcastle-on-Tyne, for the Montreal Transportation Co. This interesting vessel is to be electrically driven and has now been made the subject of a paper before the Institution of Naval Architects by John Reid and H. A. Mavor, who are concerned in her design. She is intended for service in the Canadian canals. In their paper the authors say:

The development of the canal barge or freighter presents a problem of much greater interest and importance than may at first sight appear. No one who travels on the great rivers of Europe—on the Rhine, Danube, or Volga—can fail to observe the immense traffic which they bear, and the remarkable way in which the vessels employed in such traffic have been designed to suit local conditions and requirements. It is so also on the great North American inland waterways, the importance of which, as affording the only system of transportation which can compete with the railroad, has been very generally recognized. Perhaps nowhere in the world is the influence of local conditions on vessel design more recognizable than on the Great Lakes of North America, where the immense quantities of bulk ore, coal, and grain, which have to be handled in a short six months' season, the importance of quick loading and discharge, the shallow nature of the canals and river channels connecting the lakes, and other local considerations, have led to the evolution of a very remarkable type of vessel, enormous in size, unique in proportions, and unapproachable in the efficiency and economy of its operations. The same influence of local conditions on vessel design is very marked in the Canadian vessels which make use of the St. Lawrence and Welland canals, by which access by water is maintained between the head of ocean navigation at Montreal and the end of lake navigation proper at the eastern end of Lake Erie. This canal system comprises the range of canals by which vessels are enabled to pass the currents and rapids of the St. Lawrence river above Montreal, and the Welland canal, by which the difference in levels between Lake Erie and Lake Ontario, of which the Falls of Niagara is the outcome, is surmounted.

In this series of canals the limiting draught is 14 ft. under normal water conditions, in many of the canal reaches as well as on the sills of the numerous locks. These locks themselves are for the most part of a standard size (Figs. 1 and 2), permitting the convenient passage of any vessel not exceeding 250 ft. between perpendiculars, 42 ft. 6 in. beam over plating, and drawing not over 14 ft. in fresh water. Larger vessels have been locked through, but only with difficulty, and for our present purpose it may be taken that the above dimensions cannot safely be exceeded. When it is considered that a Canadian canal vessel can only operate on the lakes and canals for six months in the year, owing to prevailing ice conditions, and that for various reasons it is not possible to employ it during the off lake season in any deep sea trade, and

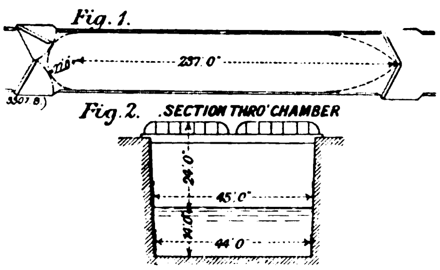


Fig. 1.
Fig. 2. SECTION THRO' CHAMBER

when it is remembered that the trade in grain, coal, pulp wood, package freight, etc., between Montreal and the Upper Lake ports, and vice versa, is already very large and rapidly increasing, it will be easily understood that not only is it of prime importance to carry the utmost possible deadweight per trip on the limiting draught of 14 ft.; but it is equally important to obtain quick loading and discharge, and to lose as little time in negotiating the canals and locks of the St. Lawrence and Welland systems as possible.

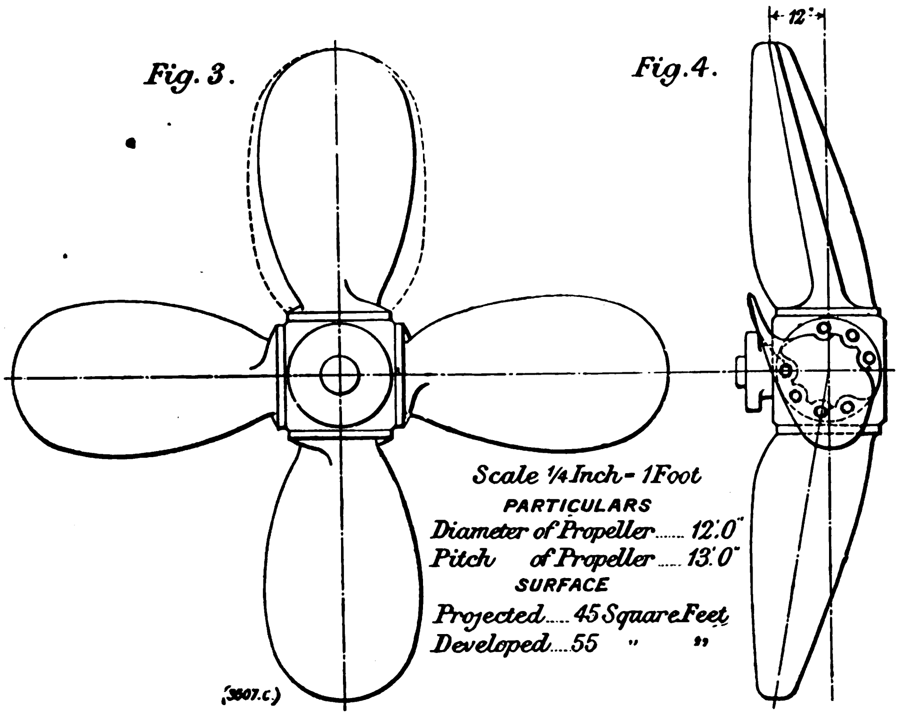
The last consideration is due to the fact that, as the speed in the canals is limited to four miles an hour, and as there is ever present in the canals the possibility of vexatious delay on account of passing vessels, railway swing bridges, waiting turn at locks, interference from fog or darkness, when the main canals cannot be navigated, etc., the vessel cannot too quickly escape into open water, where only continuous navigation at full speeds can be carried on. Under these conditions it is fair to state that anyone starting out to design or build a canal vessel suitable for the Canadian trade, without reference to the local conditions, would be pretty certain to produce a failure, however successful the vessel might be in open water alone. For example, in attempting to enter a lock which is only 45 ft. wide with a vessel which is 42 ft. 6 in. beam, and under which there may only be an inch of water over the canal bottom, it would be natural to expect that the navigating officer would arrange to approach slowly, pass lines ashore, and gradually warp the vessel in. To follow such a course would probably obviate a good deal of canal damage which these vessels now sustain, but it would inevitably entail such a delay in the locks as would most seriously reduce the vessel's earning capacity. Actually the course followed is for the navigating officer, as he approaches each lock, to line up his vessel as well as wind and current will allow, and to enter at considerable speed, so as to displace the lock water past the vessel's sides as quickly as possible. Full stop a few feet short of the gate ahead is obtained by quick engine reverse, and by holding on with an extra heavy compressor to a snubbing wire made fast to a mooring pin on the quay. When the vessel has risen or descended in the lock, it is equally important to get under way again with the least loss of time, which is usually done by passing a mooring wire forward along the lock wall or canal bank, and warping out for a short distance until the propeller can get the vessel up to the desired speed.

It will be at once apparent that, under such conditions as have been outlined, the form of the propeller, its revolutions, and its control must play a most important part on the efficiency of the vessel as a canaller. Engineers experienced in this line of work look for a screw which will cause this very full-formed vessel to respond immediately to its actions, and, of course, there goes with that an arrangement of propelling machinery which must respond immediately to the demands of the engineer in charge. A quick-acting throttle and an instantaneous and positive reverse are

all important. These would be valueless, however, to the desired end but for a propeller which will enable the vessel to be driven into and out of a lock with the least loss of time. Bear in mind that in entering the lock there is a direct resistance from the water throttled in front of the vessel, and in leaving the lock a corresponding vacuum tendency behind the vessel, and a refusal of the water to flow quickly through the restricted channels between the vessel's sides and the lock walls towards the propeller. Evidently, for successful work under such peculiar conditions, everything depends on the propeller. Note that there is no question here of hull form; that is to all intents and purposes fixed and unalterable. It will be understood that if a Canadian canal vessel has to pass every week through a hundred or more locks, and if the time lost in locking can vary from 70 hours per week for an unsuitable type to 40 for a well-designed and well-handled canaller, it may be well to design rather to overcome the lock and canal delay than from mere considerations of the best speed obtainable in open water, especially as the time which many of these vessels spend in open water is very short.

It has been found, for example, that by the use of a very broad-bladed propeller, with a pitch ratio of 1.1, and at about 80 revolutions per minute, the best results can be obtained in locking operations. The propeller is so designed that it has great driving power ahead and astern in locking operations, quickly decelerating and accelerating the speed in maneuvering into or out of a lock, as the case may be. A type of lake propeller is shown in Figs. 3 and 4. If, in imagination, the vessel shown in Figs. 5 to 10, be placed in one of the locks, which it absolutely fills, it will be easily realized how helpless for efficient results any small fine-pitched high-speed propeller would be, however excellent that type might be in open water work. Furthermore, in lining up to enter a lock, the broad-bladed Canadian propeller can be utilized to throw over the stern of the vessel without occasioning headway by giving the big, coarse screw a short full-speed impulse with the rudder hard over. This is done as a last resort in entering a lock to prevent a foul entrance, the occurrence of which generally results in a heavy blow on the one bow, a rebound with a blow on the other bow, and, finally, a severe nip abreast of No. 1 or No. 2 hatch, with the inevitable consequence of serious structural straining, leaky rivets, and damaged cargo.

Fig. 3. Fig. 4.



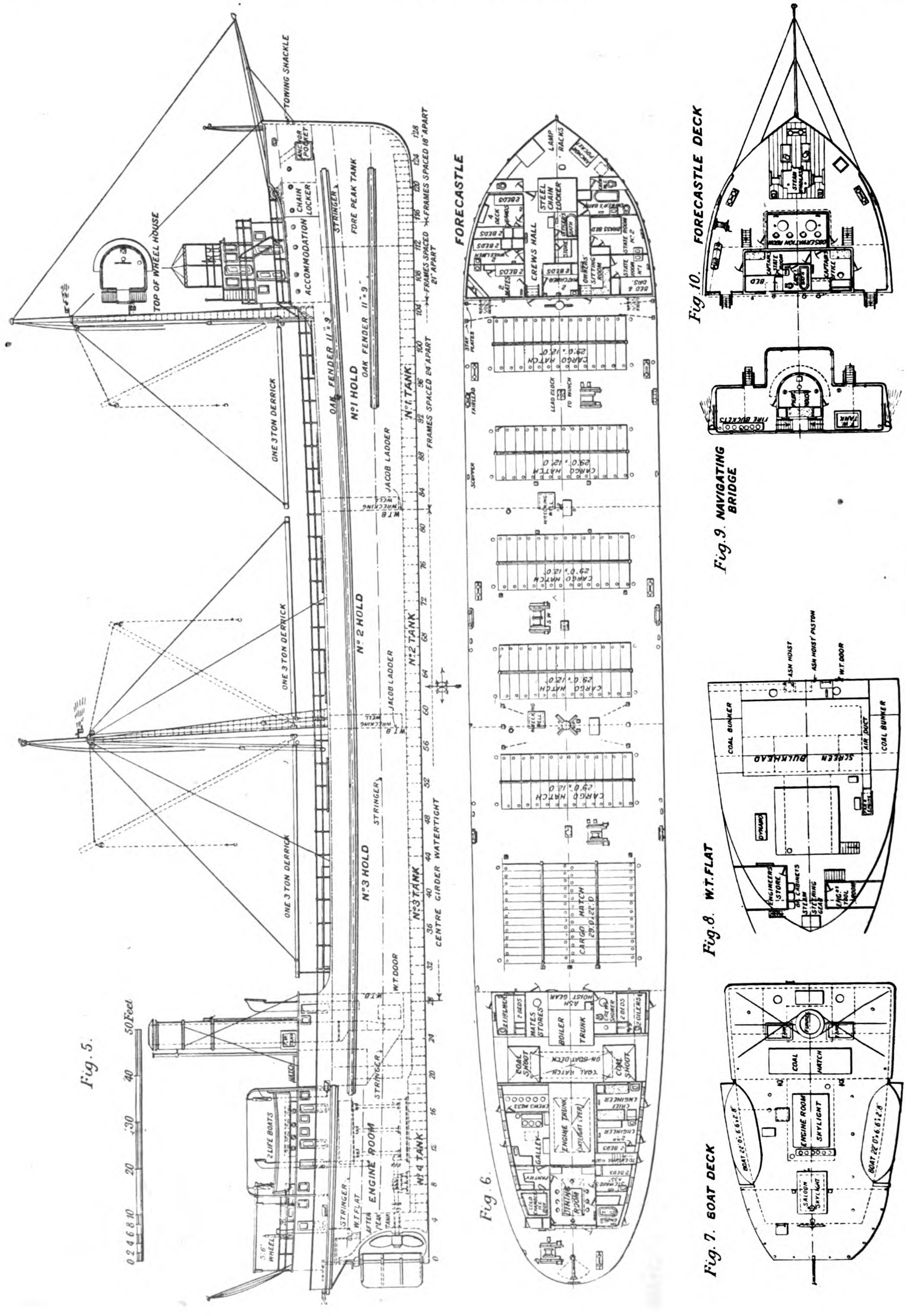
When the design of the hull, Figs. 5 and 6, is carefully considered, it is found that other circumstances, for the most part also arising from local considerations, militate against any advantage being taken of the fact that these vessels trade in comparatively sheltered waters, to reduce the scantlings, in an effort to add to the dead-weight the main scantlings, framing, and plating must be fully up to deep sea requirements, apart altogether from the fact that these vessels, being largely built in the United Kingdom, have to make passage to Montreal, generally in a two-thirds full load condition, over the stormiest region of the Atlantic. It is essential, in fact, to have even stronger close-spaced main framing forward, almost as if providing against ice, to enable the vessel to resist the continual pounding against the lock walls and approaches, to which it is inevitably subjected in this canal trade.

The double bottom must be deep, so as to provide ample water ballast to get the vessel well immersed in ballast trim, otherwise canalling and locking become impossible in a high wind, a great cause of lost time for badly designed vessels. The bottom plating must not be less than 1 in. to resist occasional rubbing in the canal; the tank top plating must be equally heavy to withstand blows from the unloading grabs; the bilges require 23/40 for protection against canal bank rubbing; and the decks must be heavily plated and well supported for deck cargoes of pulp wood and lumber, which may be stacked as high as 14 ft., 16 ft., and even 20 ft. above the deck.

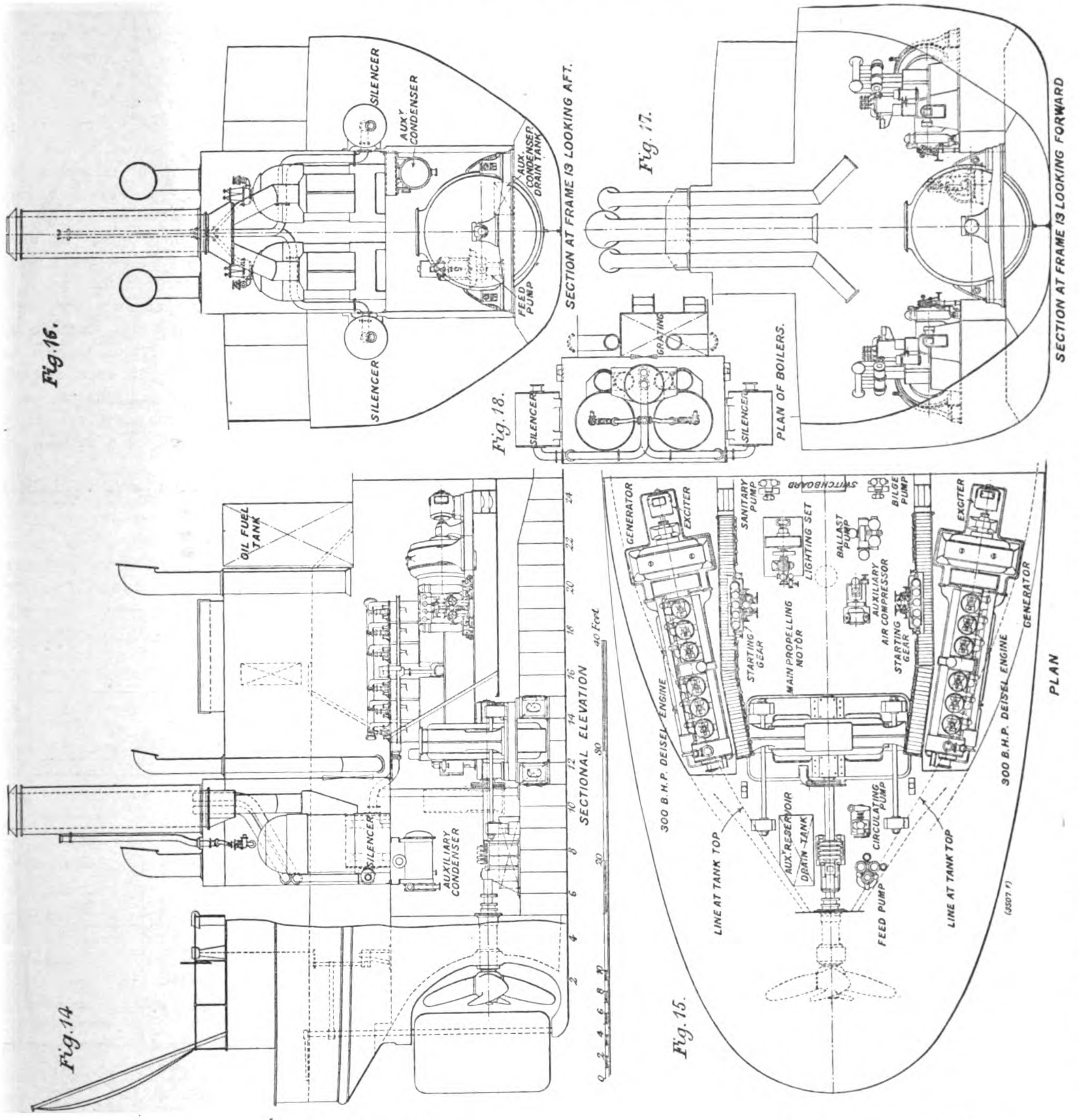
Limitations of Design

Under these conditions, if an attempt is to be made to increase the dead weight carried on the canal draught of 14 ft.—and owners are perpetually urging such increase—it is found that a limit is soon reached beyond which no reduction in weight of scantlings is possible, and as the form is usually 0.83 block, or fuller, the dead weight capacity cannot be materially increased by any changes in hull form or structure. In a word, the designer is bound hand and foot as to dimensions, form and hull weights, and is therefore driven to reconsider his propelling machinery in an effort to economize in the weights of machinery and fuel. It is this fact that makes this class of vessel a most natural type in which to experiment with the internal combustion marine engine of the Diesel or other type. First efforts, however, were devoted to adapting the gas engine and producer, because, while fuel oil is very plentiful and cheap on the lakes, coal of all kinds, including anthracite, is even more widely available, and at very reasonable rates. Therefore, it was natural to consider the producer gas proposition in the first place.

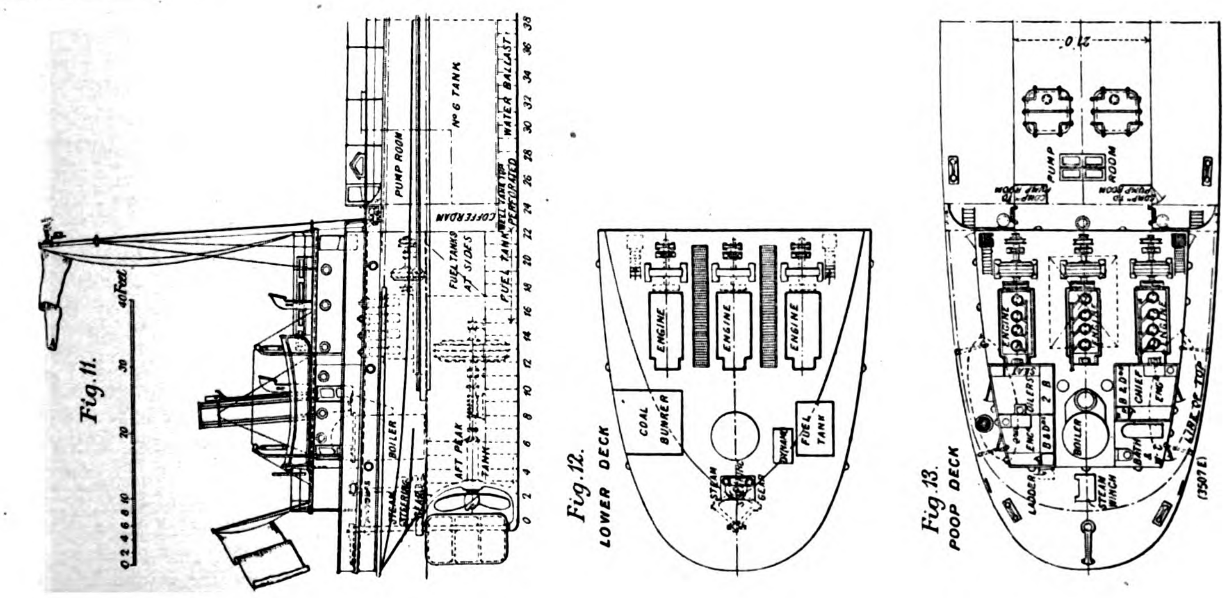
In 1908-9 the marine gas engine had not been reduced to any very practical or reliable form, and the land engines built and running offered very little in the way of experience to guide one in adapting them to marine work. Reliability was doubtful, reverse uncertain, revolutions much too high, and reduction gear at that time by no means to be relied upon. Finally, the



PROFILE AND DECK PLAN OF ELECTRICALLY-DRIVEN SHIP



SECTIONAL VIEW OF ENGINE ROOM OF ELECTRICALLY DRIVEN SHIP



attempt to adapt the gas engine was reluctantly abandoned, and the experience of other investigators in this field goes to show that this was an escape from an adventure full of trouble. One thing, however, the writers' investigation did indicate, and that was that no internal-combustion engine then extant could be coupled direct to a lake type of propeller, and that to substitute a suitable type of propeller for the proposed engine, regardless of local requirements in Canadian waters, was to court certain failure under the conditions indicated above. Mechanical reducing gears, though considered, did not offer any great prospect of success, because the reversing gear on the main engines had to be retained, which certainly promised another source of weakness and loss in canalling, possibly a failure to start or to stop under conditions as regards locks and gates certain to result sooner or later in serious disaster. At this time electricity seemed to offer possibly the best prospect of successful solution to this problem. Being satisfied that the single lake type of propeller and the facilities for maneuvering the same under steam would have to be retained if failure was to be avoided, it remained to find some third feature through which the desired large, slow turning propeller could be reconciled with the comparatively light high speed internal combustion engine of the Diesel or other type. It must be admitted that the introduction of electricity for this purpose, while committing one to a certain loss in transmission, gave assurance of certain incidental advantages of great value which had not originally been anticipated.

Simplicity of Reciprocal Engine

No internal combustion engine, Diesel or other, known to the writers, is an absolute substitute so far as simplicity of operation and reliability of handling are concerned for the ordinary up-to-date triple expansion steam engine, even in deep sea go-head work, much less in maneuvering in narrow waters within harbor limits or in rivers or canals. Whatever success may have been obtained by the recently developed two-cycle, slow speed, marine type of Diesel engine—and there is here no suggestion that success has been other than most encouraging—it still seems that the line of development followed is not such as appears likely to lead to the evolution of a propelling engine, which an owner will be as ready to have in his vessel as he would an ordinary steam outfit. Attention has been paid to obtaining a specious resemblance to the marine steam engine in an effort to make the Diesel engine exactly suited to take the steam engine's place direct on the propeller shaft for the sake of a simplicity which is more apparent than real. To get the low revolutions most desirable for propulsion in slow speed cargo vessels, important advantages in the normal Diesel engine, such as high speed, low weight, and moderate over all dimensions, have been sacrificed, while the necessity for fitting reversing gear on the engine itself has added a most unfortunate complication, necessitating the lavish use of compressed air in maneuvering, an addition of a particularly troublesome and expensive nature. Furthermore, experience has already shown that the use of large single screw Diesel engines in propulsion is attended with grave risk of the breakdown of the whole propelling mechanism of the vessel.

It is idle to deny that there is inherent in the very operating principle of the Diesel engine an element of delicacy and unreliability very little in keeping with the rough work of marine propulsion, from which the modern steam engine emerges with credit. The fuel economy which has been the one real outstanding claim for the adoption of the Diesel engine is, in fact, dependent on an operation of great nicety, involving the use and maintenance of very delicate mechanism. A governor action controlling this mechanism is set in motion by the racing of the engine in a seaway, and the cycle of the cylinder operations, so far from continuing uniform, as is essential for good working, are periodically interfered with, probably under impulses given too early or too late, with inevitable trouble. It must be considered also that no engine of the Diesel type, with its numerous spring-loaded, cam-driven valves and other fine-set gear, can take kindly to the vibration set up by the action of a vessel in a seaway. The reference here is particularly to a vessel engined astern, but the same is true of any position of the machinery in direct drive. Finally, any adjustments necessary on the Diesel engine, need for which may not be at once apparent—in fact, which may not become apparent at all until serious trouble has developed—must be at once attended to, to avoid trouble, whereas in a steam engine they may without serious detriment be put off to a suitable opportunity.

Fig. 19. DESIGN FOR DREDGER WITH ELECTRIC PROPULSION

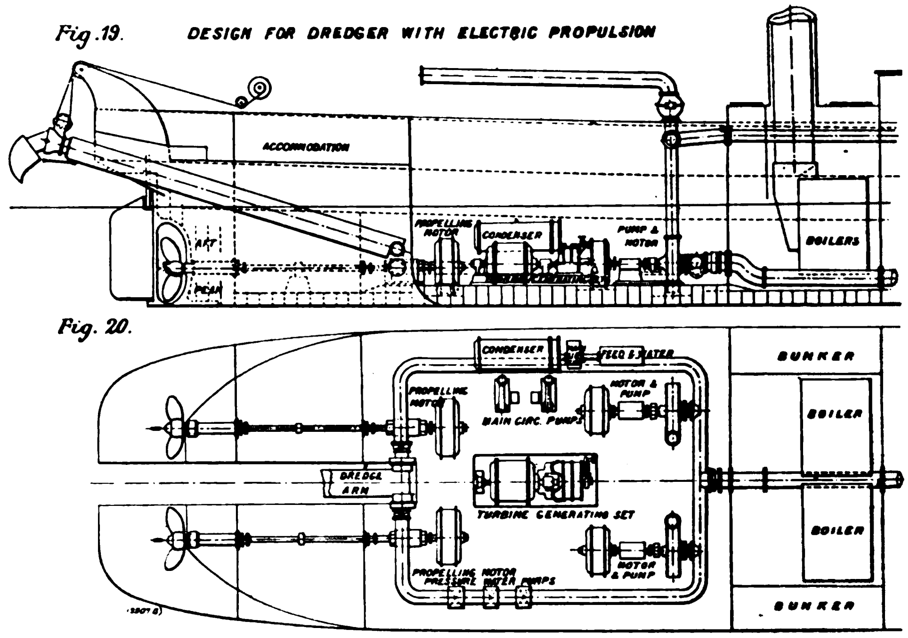


Fig. 20.

Enough has been said to indicate some of the points which experience has already developed as requiring consideration in the present Diesel type of marine engines before its reliability can be confidently placed in the same category with that of the triple expansion steam engine. After all it is the average ship owner's wish to have a ship which, while attaining all reasonable efficiency and economy in its operations, shall be, first and foremost, trustworthy, and the propulsion of which will be carried on as surely as the limitations of the best engineering mechanism will permit. It is hopeless to introduce new methods of marine propulsion which do not guarantee all the security and certainty of the mechanism which they displace. Therefore it is suggested that it is unfortunate that so much effort has been devoted to attempting to force the Diesel engine into conditions of service for which it appears

inherently unfit, without saying that in certain classes of vessels where the conditions are special there may not be a perfectly legitimate field for the type criticized—viz., the direct-drive, slow-speed, two-cycle open marine engine. Such scope is most assuredly not found in the full-bodied cargo boat, still less in the Canadian canal vessel, under the peculiar conditions and limitations above described. It is unthinkable that, with its present form of hull, which cannot be varied, and the still more definitely fixed type of propeller, the present triple-expansion engine can be displaced by any direct-connected Diesel engine. Eighty revolutions per minute, which is common with the steam engine, is almost hopeless for the Diesel, and however successfully the reversing gear may operate in the latter engine, it is little likely to be improved by hundreds of rapidly alternating go-ahead and go-astern motions required in negotiating such a series of locks as in the Welland canal.

Introduction of Electricity

Broadly speaking, the introduction of electricity in this connection puts the Diesel engine back into work for which it is eminently suited, under conditions which give it every chance to maintain efficiency and reliability. It is as far as possible removed from the uncertain action of the propeller, and the uneven loading and vibration incidental to a direct propeller drive. In Canadian canal work the power required for propulsion varies between very wide limits. In the canals themselves, four miles being the limiting speed, 150 i. h. p. or less is sufficient, though full speed must be always available for emergency, especially in backing. In the open lake in fair weather 500 i. h. p. is sufficient to maintain fair speed, while 750 i. h. p. is necessary in contending with the St. Lawrence currents. In some designs the writers, therefore, proposed three Diesel generating units of 250 i. h. p., each of which can be switched on to the propelling motor as required. Such an arrangement is shown in Figs. 11, 12 and 13. In the Tynemount, which is now building, to demonstrate the Diesel-electric arrangment of propelling machinery, a two-unit subdivision is arranged for, each unit furnishing 300 b. h. p. Figs. 14 to 18 show approximately the general layout of the installation and attention is directed in this illustration, and also in Figs. 11 to 13, to the ease with which the generating units can be located in any desired position, in a separate engine room remote from the propeller motor, or on an upper flat, or as may be considered convenient.

The electric system adopted is that identified with the name of the second writer, involving the use of alternating current. Investigation and actual tests have amply shown the suitability of this system for marine propulsion. This system has for its special object the simplification of the electric equipment. Many applications of electric power have been made to marine propulsion, but hitherto, with the exception of the Electric Arc, propelled on this system and built in 1911, continuous currents only have been used, the reason being that regulation of speed and control is easier for continuous current under ordinary conditions than for alternating current. The disadvantages attached to the use of alternating current in respect of regulation are associated with the greater number of conductors and particularly with the property of alternating current motors, that the speed of the motor bears a fixed ratio to the speed of the generator, and that any departure from this speed is associated normally with loss of efficiency and with more or less complicated devices for changing the frequency of the current alternations.

In the system under notice these difficulties are overcome by the use of more than one frequency applied to each individual motor. The currents of different frequency are carried in independent, mutually non-inductive circuits, the magnetic systems being entirely independent, but operating upon a common rotor, so that their mechanical effects can be superposed and the power transmitted in the separate circuits combined to produce the required mechanical effect. The required currents may be obtained from one or more generators.

The Tynemount

In the vessel now under description (the Tynemount) the equipment consists of two three-phase generators driven by Diesel engines running at 400 revolutions per minute. The electrical output from each set is 235 kilovolt-amperes at 500 volts alternating. The generators have 6 and 8 poles respectively, giving frequencies of 20 and 26.6 per second. The exciting current is obtained from direct-connected continuous-current machines on the same shafts as the alternators. The normal exciting current is 30 amperes at 100 volts. A single three-phase motor is coupled direct to the propeller-shaft, which is of the ordinary type with marine thrust-block. The motor develops 500 shaft horsepower. The rotor or moving part is of the simple squirrel-cage type, without any electrical or mechanical connection other than its rigid attachment to the propeller-shaft. The stationary part of the motor has two separate non-inductive windings for 30 and 40 poles respectively. When each of these two windings is connected to the appropriate generator, the speed due to each is 78 revolutions per minute. By changing the connection on both windings, the direction of rotation is reversed, and by connecting the 40-pole winding of the motor to the 6-pole generator, the speed in either direction drops to 58 revolutions per minute, or about three-quarters of the full revolutions. If full speed be not required, one generator may be stopped and the other left running at full revolutions under governor control and at full economy, because the power required to drive the ship at three-quarters speed is about half of that required to drive it at full speed. If either of the generators be left attached to its own winding and the other generator shut down, the ship is propelled by either engine at a little over half-speed, the speed of the ship falling with the speed of rotation of the engine, until an automatic adjustment of power and speed is reached at about half-speed.

Control Gear Apparatus

The control-gear consists of an apparatus for changing the connections of the generator and motor windings respectively. There are five positions on the switch, corresponding to the ordinary positions on the engine-room telegraph. They are "Full Speed Ahead", "Half Speed Ahead", "Stop", "Half Speed Astern", and "Full Speed Astern". Each position of the controller is definitely fixed by means of cams and rollers, so that stopping at intermediate positions is prevented. The controlling gear provides for the interruption of the excitation of the generators while the switch is being moved from one step to another, the exciting switch and the main switch being interlocked so that the switching-over operation is accomplished while the electric circuits are "dead", thus avoiding injurious sparking. Should it be found convenient, a very simple arrangement could be made whereby the control could be operated from the bridge of the vessel, and the engineer's attention confined to the keeping of his engines lubricated and supplied with fuel to run at constant speed. It will be seen that this method of control entirely dispenses with the stopping and starting of the Diesel engines for manoeuvring, an

operation which, in itself somewhat difficult, becomes impossible if a liberal supply of compressed air be not available. To keep up a supply of compressed air for manoeuvring the vessels in the locks and channels of a canal involves the upkeep of a very expensive and inefficient air-compressing plant, and the dispensing with this auxiliary is a very important feature of the system. It is also advantageous to have two units, each capable of driving the ship, so that in the event of an interruption to the running of either the vessel is still under control.

Functions of Electrical Equipment

The functions performed by the electric equipment may be recapitulated:—

1. It adapts the speed of the engine to the speed of the propeller.
2. It combines the power of separate engines and applies the whole to a single propeller, with perfect freedom to use either or both power units.
3. It provides a simple and easy reversal of the propeller, while leaving the engines running in one direction at constant speed.
4. It also provides ready means of distant control should this be required.

It will be seen that the use of mechanical gearing could perform the first, and the first only, of these functions, and for this reason it is anticipated that, compared with a mechanically-geared or direct-connected Diesel engine equipment, the electrical equipment will offer very material advantage in the operation of the vessel in the special circumstances under which it is placed.

The writers have endeavored to show how important, and, indeed, even indispensable for reliability and efficiency, the use of electric transmission may be in the propulsion of so relatively simple a type as this Canadian barge where it is decided to adopt the Diesel engine. This should help to dispose of the too prevalent idea that the natural scope for electrical propulsion is in war-ships or other highly specialized vessels, in which electricity might provide means for adjusting economically the power generated to the very conflicting power requirements, say, under peace and war conditions. Undoubtedly a battleship or battle-cruiser does offer the very best scope for the electric drive, but only because that class of vessel presents on a large scale the same problems in propulsion which are found in almost all other vessels—viz., how to adjust efficiently and economically the power available to the power required at any given time, not necessarily always from the point of view of propulsion alone.

From the analysis of the voyage logs of an ordinary tramp steamer, the second writer has shown (see *Electrician*, June 10, 1910,) how important towards efficiency of propulsion might be the introduction of electric transmission, with the added economy of a modern high-speed reaction turbine as the power-generator in place of the usual triple-expansion engine, and, of course, in this case such possibilities of economy are confirmed by the results since obtained with mechanical gearing introduced for the same purpose. An advantage, however, lies with the electrical arrangement, in that it permits a much wider range and variation of revolutions between the propeller and the turbine, permitting also a more advantageous subdivision of the generating plant into units of different sizes, and finally eliminating the necessity for reverse in the turbine and simplifying the control.

In the United States, Mr. Emmett, of the General Electric Company, has also shown the suitability of electric propulsion for a deep-sea collier of great size and 7,000 h. p, for which the equipment has already been completed and tested with the most brilliant results. From such a vessel to a large passenger liner such as the Celtic is a mere step, and in such vessels also the possibilities of economy and all-round efficiency are most marked.

General Efficiency

In such matters it is much too common to pronounce judgment for or against without adequate analysis of the problems which are as numerous and varied as the vessels which come up for consideration. In this connection, trial-trip data, however valuable for comparative purposes, cannot be used as a guide, because what we are concerned with is maximum efficiency in working conditions; not propelling efficiency alone, but the innumerable phases of the working of a ship, of which propulsion is, perhaps, the most important, all of which have a bearing on the general efficiency of its operation. Experience in developing a comparatively simple type, such as this Canadian canal vessel, shows that it is frequently quite impossible to convey to the builder any adequate conception of how such a vessel is handled, and has to be handled, to get maximum efficiency out of it in the short six months' season. What Lord Kelvin used to call the "bias of preconceived notions" is apt to prevent a detached view on the part of a builder, especially when a decided departure from established practice and precedent is called for. For example, the idea that special scantling provisions forward should be fitted to any type of vessel to enable it to "butt" stone walls and quays with impunity seems to many builders very unreasonable, though the same builders might not hesitate to fit special bow stiffening against ice.

Scope in Marine Propulsion

It is for this same reason that one is not surprised to meet with considerable scepticism in regard to the scope for electricity in marine propulsion. To the majority of sea-going engineers the idea of a transmission feature between the driving-engine and the propeller is simply anathema. To prevent such an introduction an infinity of pains will be devoted to experimenting with high-speed propellers and low-speed turbines and oil-engines with an all-round lowering of total efficiency and an increase in complication actually in excess of that which it is desired to avoid. There are not 10 per cent of the merchant vessels now afloat which would not be most efficiently propelled by screws designed to turn at revolutions not exceeding 80 per minute, and for real progress towards maximum efficiency in marine propulsion one should at all costs retain the simplest form of propeller, the efficiency of which permits of no dispute, and from that basis arrive through the various methods of transmission now available at an arrangement of machinery best suited to each individual case. At the start such a scheme of powering a vessel would work a hardship on the builders of standard marine machinery; but it should be understood that, in advocating the use of transmission gearing, one does so to enable the newer forms of power generators to be utilized.

Nothing is more likely to retard the introduction of the internal-combustion engine in marine work than the mistaken attempt to treat it as a perfect substitute for the triple-expansion engine which it is intended to displace. It is at this point that electricity acts as a safeguard in a way that no other system of transmission can approach.

There are, of course, problems of propulsion, the analysis of which shows that approximately equal results may be obtained whichever form of transmission gearing—electric, hydraulic, or mechanical—is adopted. In such cases the decision will, no doubt,

lie with that system which offers the greatest reliability and simplicity of operation. The success which has attended the introduction of the geared turbine and the hydraulic transformer is of good augury for similar success with electric transmission. But there is a class of problem in marine propulsion for which the only possible solution is through electrical means—viz., vessels in which propulsion is only one, and sometimes not the most important one, among many functions calling for power, which it is evident would be most efficiently provided from a central generating station. Among such vessels one might class the larger sizes of warships with their multitudinous requirements in power for the driving of auxiliary engines as well as propelling machinery, but for purposes of illustration it is probably better to take a simpler case, such as a dredger, say, of the self-propelled suction type. Attention was first called to the suitability of electric drive for such vessels by Professor Biles and H. A. Mavor, and John Reid has recently completed a design for a large vessel of this class which clearly indicates the very important advantages which may be obtained by the introduction of a central generating station furnishing power as required to the propellers, the dredge-pumps, or the numerous auxiliary machines.

Layout of Engine Room

Figs. 19 and 20 show the general lay-out of the engine room in which there is a single generating turbine plant, with electric motors on the screw shafts and also on the dredge pumps. In a similar steam-driven job there are four separate triple-expansion engines, two for propulsion, each of 800 i. h. p., and two for the pumps, each of 500 i. h. p., or a total of 2,600 i. h. p. When it is considered that the introduction of the electric system allows the total horsepower generated to fall back to 2,000 as a maximum without in any way prejudicing the operations of the dredger, it is at once apparent that here we have a first-class incentive to adopt an electric arrangement. A further incentive of great importance in such work is the ability which the use of electricity confers to place the complete control of the dredger in the hands of one man, the dredger master. Here, again, we have evidence of the importance of studying such a problem rather from the side of the dredger-operator than from that of the dredger-builder. No real progress can be made until this is done. By a simple system of switches scarcely more complicated than ordinary bridge telegraphs, one man can handle the whole machine directly with the very greatest advantage to the efficiency of the dredging operations.

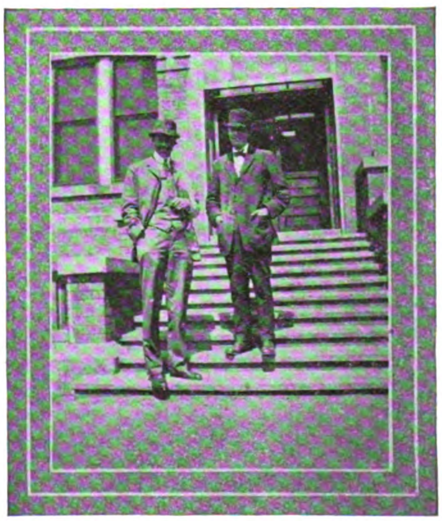
Such are some of the most likely cases in which electricity seems to offer a means of solving certain difficulties in the power question, which are, after all, only components of a problem which, in one form or another, has long confronted the marine engineer—viz., how to generate the power required in a given vessel independently of the means used for propulsion, enabling the source of power for all purposes to be concentrated in a central station with a simple, economical, and easily-controlled system of distribution, by which the power generated for any particular purpose may be exactly related to its requirements.

Algoma Steel Corporation

Some Reference to Its Producing Capacity, Dock Equipment and Personnel

THE plant of the Algoma Steel Corporation, Sault Ste. Marie, Ont., embraces an area of over 100 acres and is exceedingly well arranged for the expeditious handling of material. At present the output is devoted exclusively to steel rails, splice bars and tie plates. The rail mill is running night and day producing 1,200 tons of rails every twenty-four hours while the merchant mill operates in the day time only, running three days per week alternately on splice bars and tie plates. The demand for these products from the Canadian railways is heavy and the plant is booked for over a year ahead. In fact, it could market 2,000 tons of rails per day were it able to produce them. Two-thirds of the steel produced in the plant is Bessemer at present, though it is the intention of the management to gradually reverse this proportion and to eventually make the plant an open-hearth proposition exclusively.

During the present season the corporation is receiving but little ore from its Helen mine in the Michipocoten district, selling the output to other consuming interests. It is operating No. 1 furnace with 70 per cent Canadian ore from stock piles and is using some ore from its Magpie mine, which, however, has to be roasted. The corporation has three furnaces—two 250 tons and one 450 tons—and handles over its docks about 600,000 tons of ore per annum.

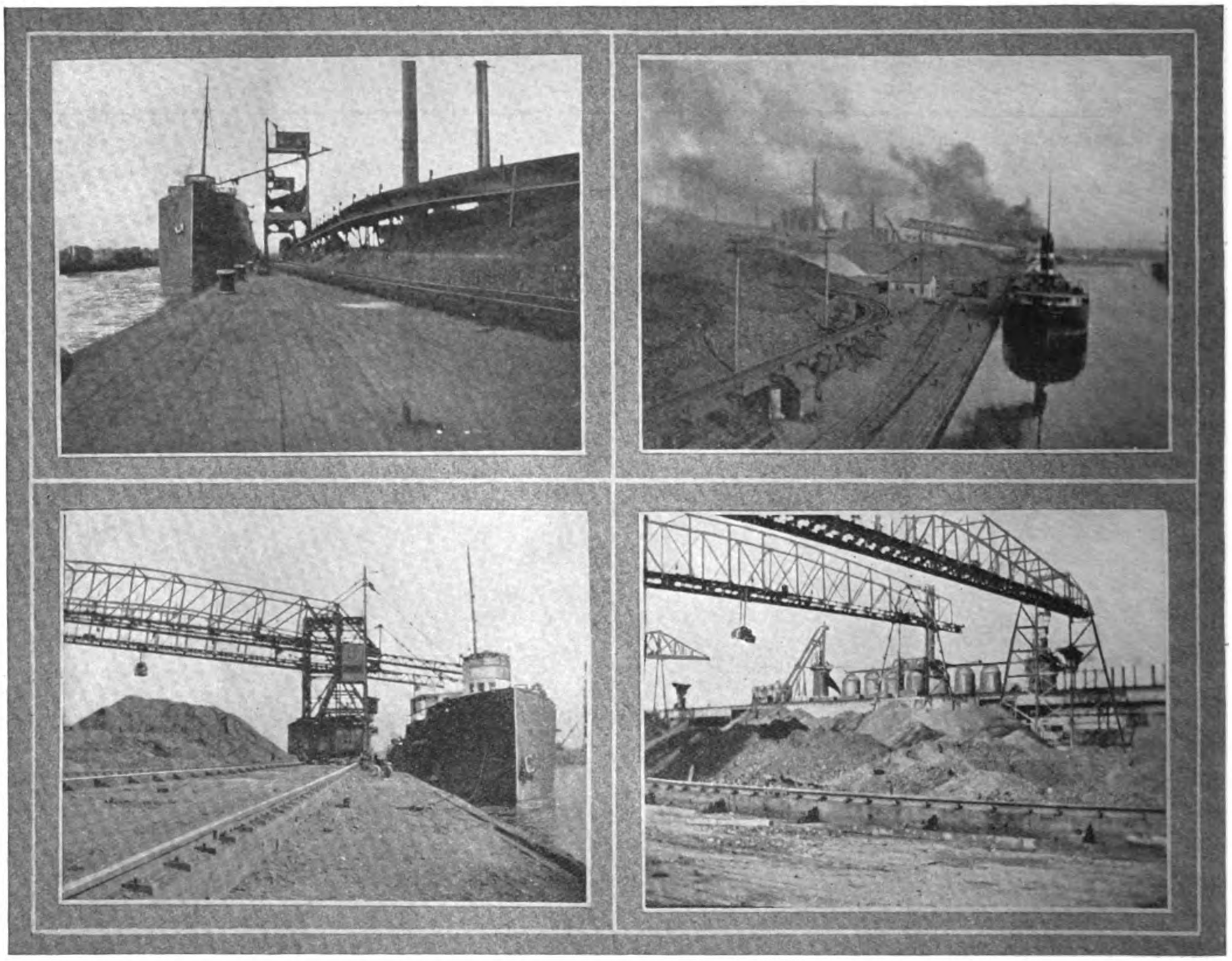


SAMUEL HALE, GENERAL MANAGER, AND C. E. DUNCAN, GENERAL SUPERINTENDENT

The ore handling equipment was installed by the Wellman-Seaver-Morgan Co., of Cleveland, and consists of three machines operating 3-ton self-filling buckets and are capable of unloading about 134,000 tons a month. The three machines rarely work in a boat simultaneously, one of them being usually employed constantly in charging the furnaces. The ore buckets dump in storage and can also unload directly into cars for charging the furnace bins, from which place the ore is carried by belt conveyor to the skips which travel to the furnace mouth. Two vessels have recently been added to the ore carrying fleet—the Franz and Frater (formerly the Uranus and Saturn of the Gilchrist line)—and carry about 5,500 tons each. The average time unloading and taking care of furnaces meanwhile is 27 hours, which is a very

fair performance considering the distances that the buckets have to travel to stock pile and furnace cars. Like everything else about the plant the ore unloading machinery is electrically driven.

The coal handling equipment was installed three years ago and is of the Heyl-Patterson type, consisting of two rigs operating 3-ton buckets. This is a very interesting installation. While it was only guaranteed to unload a work of unloading is thrown upon one rig, which makes for delay. The secret of rapidity of dispatch in this installation lies in the short distance that the buckets have to travel. The buckets unload into a hopper which is carried in the rig and as the whole equipment operates on tracks, the outer rail of which is within three or four feet of the face of the dock, it can be seen that the distance from the vessel's hold is very short indeed. In fact, observafore, as soon as he gets under the hopper inserts the plug connection, opens the hopper bottom and receives his load. He then closes the hopper bottom, withdraws the plug, and carries the coal to the storage pile. The cars, operating on the third rail system, are carried on a trestle work and dump that load at will on either side of the trestle. They are designed to carry 20 tons but in actual practice carry about 22 tons which they dump in from



PERSPECTIVE VIEW OF COAL RIG AND TRESTLE; PERSPECTIVE VIEW OF ORE UNLOADING MACHINES AND BLAST FURNACES
STEAMER FRATER UNDER THE ORE RIG; ORE CONVEYING BRIDGES AND BLAST FURNACES

10,000-ton steamer in 48 hours, it has been speeded up to do the job in 32 hours and with certain modifications which the experience of the past three years has demonstrated the wisdom of, can be made to do even better. With the installation of another unit vessels can be assured of rapid dispatch at this dock. The design of the equipment is excellent and conducive to dispatch and the only criticism of the present installation that can be made is that it is a bit light for the work and temporary breakdowns are therefore to be expected. When they do occur the tions taken at random indicated that the buckets averaged a rund trip in less than forty-five seconds. The operation of the bucket and the movement of the rig along the tracks to get in line with the hatches are both controlled by an operator carried in the rig; but he has no control over the hopper itself. The hopper has a capacity of about 80 tons and discharges into a car which not only carries its own motive power but through a plug connection with one of the legs of the rig controls the hopper bottom as well. The operator in the car, theretwo to three seconds, returning immediately to the hopper for another load. As the capacity of the hopper is about four times that of the car, the unloading buckets are never delayed waiting for the car to return. One car can conveniently take care of one hopper, though a third car is held in reserve should anything happen to either of them. This unloading equipment will conveniently handle from vessel to stock pile 175,000 tons per month.

As stated, everything about the plant is electrically driven, and the simplicity of the thing is amazing. The bloom-

ing mill is operated by an electric reversing equipment designed to roll 75 tons per hour from ingots 20 by 20 inches into billets 8 by 8 inches in fifteen passes. The rolls are driven by two 600-volt direct-current motors mounted on the same shaft. The reversal is made in about three seconds.

The rail mill is a model of its kind. Three sections of a rail from every heat is tested under a drop hammer and if cracks result in two of the three sections, the entire heat is rejected. The operation of the mill is practically automatic even to the loading of the railway cars which enter the mill upon sunken tracks, the rails sliding upon the cars broadside from the rolls. The cars are then made up into trains for the Algoma Central railway or are merely switched to the dock to be unloaded into steamers operated by the Algoma Central Steamship Line, which controls a fleet consisting of the steamers Agawa, Franz, Frater, Thomas J. Drummond, Leafield and Paliki.

The coke ovens, built by H. Koppers, Joliet, Ill., are designed on the principle of conservation of resources and demonstrate very clearly the downright criminal wastefulness of the old type of coke oven, of which there are plenty yet left in the Connellsville region. These ovens not only supply sufficient gas for all the furnaces in the boiler plant, but furnish a surplus which is piped to two leading industries at the Sault. The by-products are sulphate of ammonia and tar. Both find a ready sale. The sulphate of ammonia is in good demand as a fertilizer, bringing $70.00 a ton, and is shipped all over the continent. The tar is sold to a consumer in Sault Ste. Marie. This conservation pays for the cost of the raw coal.

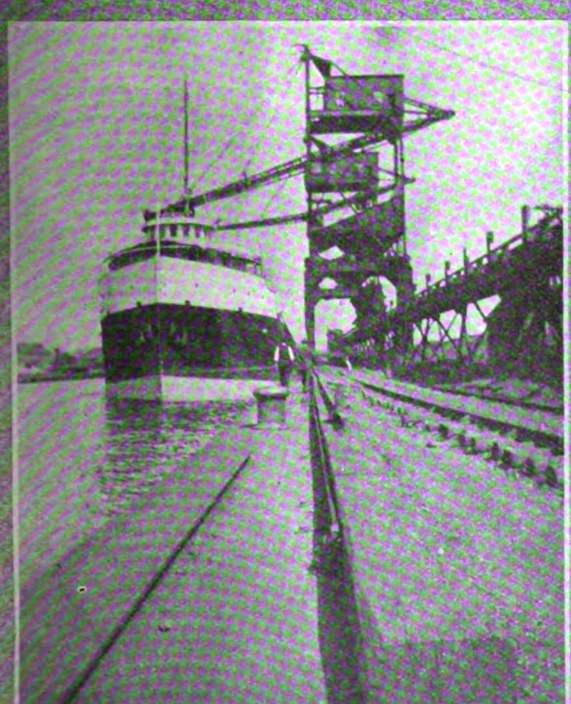
The Coke Ovens

The coal for coking is conveyed from the boat either to storage or the coal hoppers. It is carried from these hoppers by a belt to the coal breaker and crusher building where it is broken and the iron particles removed by a magnetic separator. The coal is then crushed and conveyed by a belt to mixing bins from where it is carried to the 2,000-ton coal storage bin. By means of hand-operated gates which are located in the bottom of the coal storage bin, the coal charging car receives the coal from the bin for charging direct into the tops of the ovens. The coal is baked from 18 to 24 hours and the ovens have a producing capacity of 1,200 tons per day. The means of emptying the ovens of the living coke is both interesting and picturesque. A pushing machine operating on one side of the oven literally pushes the coke out through the other side. As it emerges from the oven in a compact and practically incandescent cake, parallelogram in form, portable latticed gates guide it across the pusher platform over the edge of which it falls into a waiting car in which it is immediately taken to the quencher, where liberal streams of water are poured upon it. It is then conveyed either to storage or directly to the furnace.

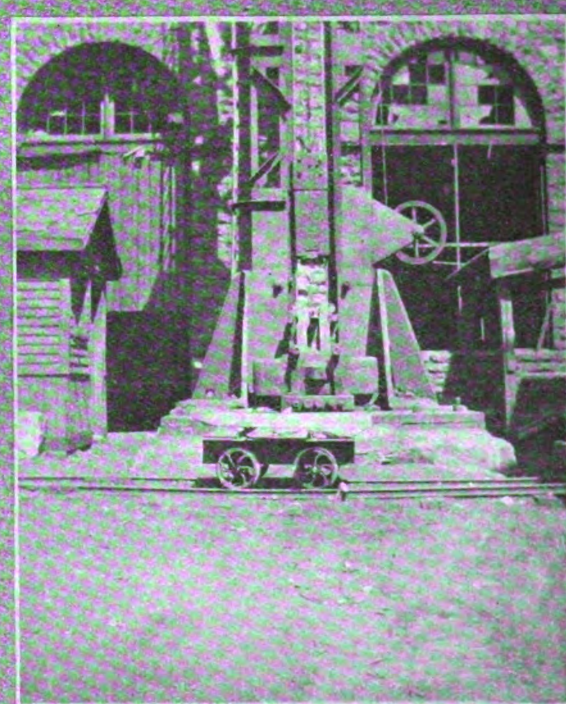
The corporation's gas engine equipment consists of nine units housed in an imposing structure and all are driven by gas from the blast furnaces. The equipment consists of four blowing and five power engines. There is also an emergency steam plant consisting of a reciprocating engine and a turbine which is driven by the exhaust steam.

Concerning the personnel of the Algoma Steel Corporation, its distinguishing characteristic is its youthfulness. It has been found practically impossible to transplant to so comparatively remote a settlement the older element bred in the Pittsburgh district and the reason is not far to seek. Their homes are well established, their children going to school and their work secure and free from hazard. Therefore, why should they change? Not so with the younger element. The spirit of adventure and the great opportunities of a growing business appeal to them and that is why the rank and file of the Algoma Steel Corporation's force are all young.

Samuel Hale, who was made general manager of the plant in October, 1912, received his early training at the South



STEAMER ISHPEMING UNDER THE COAL RIG.



THE RAIL TESTING MACHINE

works of the Illinois Steel Co. He entered the employ of that company in 1894 and rose to the position of assistant general superintendent, leaving in 1902 to build a plant for the Deering Harvester Co. This plant was later taken into the International Harvester Co. and made a subsidiary of the Wisconsin Steel Co. Mr. Hale remained with the Wisconsin Steel Co. until his appointment as general manager of the Algoma Steel Corporation in October last.

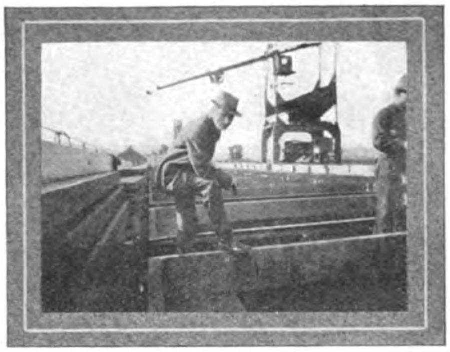
C. E. Duncan, general superintendent, has been identified with the steel-making industry since childhood. He started at Chattanooga in 1887 with his father in the South Tredegar Iron Co.'s plant and in 1892 joined the Carnegie Steel Co.'s forces as roller, in which capacity he served for ten years or until the formation of the United States Steel Corporation, when he went to the National Tube Co.'s works at McKeesport as a roller. The Steel Corporation did not take kindly to the practice which had obtained in the subsidiary plants of paying the roller on a tonnage basis and letting him settle independently with his help. It practically abolished it by cutting down the profits of the rollers. Mr. Duncan admits that it was a good thing to do as it resulted in giving the laborer better wages. Mr. Duncan left the National Tube Works to go with the Cambria Steel Co. as assistant superintendent. In 1906 he went with the Bethlehem Steel Corporation as assistant to S. B. Sheldon, where he remained until 1909, when he accepted the position of general superintendent of the Algoma Steel Corporation.

The Steamship Line

J. E. McLurg, the assistant sales manager, was until the beginning of the present year, the manager of the Algoma Central Steamship Line, in which office he has been succeeded by S. V. McLeod, formerly his chief clerk. Mr. McLeod started his career as office boy for F. H. Clergue and remained in the employ of the company until 1906, when he went with the Duluth Log Co. When Mr. McLurg was appointed as manager of the Algoma Central Steamship Line in 1907 he recalled McLeod to succeed him as chief clerk and as stated, he now succeeds him as manager of the line.

J. A. McColl, superintendent of docks and tracks, has been with the corporation since 1900. He is a graduate of Queens University, Kingston, and for a time taught high school. He later became interested in development work in the Hastings gold mining district in Canada, investigating and purchasing properties on behalf of an English syndicate.

The Algoma Central railroad is now building a new coal dock at the Sault and is installing new coal handling equipment at Michipocoten and it would seem as though some of the enterprise founded by F. H. Clergue with so much imagination and financial prodigality were destined to be great and growing successes.



J. A. McCOLL, SUPERINTENDENT OF DOCKS AND TRACKS

Oil Storage at Panama Canal

The Canal Commission is now in position to make assignments of land for oil storage at the Atlantic and Pacific ends of the Canal. It is the purpose of the Commission to install the necessary oil pumping plant at the water fronts, and to run the oil mains from there to the vicinity of the oil tanks. The area assigned for the tanks at the Pacific terminus is on Balboa dump, south of the Union Oil Co. station, and west of the railroad track to the breakwater.

S. V. McLEOD, MANAGER ALGOMA CENTRAL STEAMSHIP LINE

The ground there is from 25 to 45 ft. above mean sea level, and suitable for the erection of tanks, with little or no grading. The area set aside at the Atlantic end is immediately east and south of Mount Hope cemetery. This area was previously reserved for oil tanks for the Commission. Since then, applications, which have been received from individuals and companies indicate that private organizations will furnish sufficient supply, therefore, practically all of the area heretofore reserved, together with the area between the cemetery and the old East Diversion, may be assigned to individuals and companies, with the exception of space for two additional tanks for the Canal Commission.

The use of the land required for private storage tanks will be granted under revocable leases, or licenses. It is probable that the tanks will be required to be spaced about 300 ft. apart. In view of the fact that there will probably be ample ground to meet all demands, and, as the Commission will run its own supply and delivery pipes from the water fronts to the general tank areas, there is practically no choice of location.

Lake Superior Commerce

The commerce of Lake Superior as measured by the canals at Sault Ste. Marie was the heaviest on record during July, when 12,278,124 net tons of freight were moved, exceeding the June movement by 164,511 tons. The movement to August 1 was 37,673,487 tons as against 30,632,074 tons for the corresponding period last year, an increase of 7,041,413 tons. Following is the summary:

EAST BOUND.

	To Aug. 1, 1912.	To Aug. 1, 1913.
Copper, net tons	46,938	46,967
Grain, bushels	22,126,172	46,029,435
Building stone, net tons	2,282	5,973
Flour, barrels	2,973,074	3 878,131
Iron ore, net tons	20,245,785	23,320,802
Pig iron, net tons	5,714	16,034
Lumber, M. ft. B. M.	284,262	254,325
Wheat, bushels	55,355,445	65,259,854
Unclassified freight, net tons	99,792	209,844
Passengers, number	14,955	18,557

WEST BOUND

Coal, anthracite, net tons	505,225	1.425,554
Coal, bituminous, net tons	5,981,229	7,986,881
Flour, barrels	....	363
Grain, bushels	....	400
Mfctd. iron, net tons	290,934	182,728
Iron ore, net tons	3,188	23,240
Salt, barrels	362,286	335,136
Unclassified freight, net tons	531,467	511,221
Passengers, number	17,063	20,420

SUMMARY OF TOTAL MOVEMENT.

East bound, tons	23,266,029	27,393,691
West bound, tons	7,366,045	10,279,796
Total	30,632,074	37,673,487
Vessel passages	10,020	10,850
Registered tonnage, net	24,631,067	27,040,841

Steamer Peck Explosion

A Defective Part in the Rear Head of the Boiler is Believed to Have Been the Cause of the Explosion

GREAT interest among engineers in general obtains in the explosion of the starboard boiler of the steamer E. M. Peck, at Racine, on June 11. The steamer was unloading at Pugh's lower dock when one of the transmission cables on the unloading rig gave out, causing the work to be suspended. It was decided to move the steamer to the upper dock, a distance of about half a mile up the river, that the work of unloading might continue.

The subsequent events are best told in the language of the local inspectors, saying:

Report of Local Inspectors

"Upon being advised that the steamer would have to shift, the first officer, who was in charge of the steamer at the time, went below to the engine room and advised the chief engineer, that the boat would have to go to the upper dock. The chief engineer replied that it would be all right, and that he wanted about 15 minutes to warm up the engine and to get ready.

"At about 10:25 a. m., the first officer again went to the engine room and asked the chief engineer if he was ready, and the chief replied that he was and that it would be all right to start. The first officer then went to the bridge and worked the steamer away from the dock. In handling the steamer around the dock, the engine at no time was working strong. He blew the whistle for the bridge which is only a short distance away, got his boat pointed for the draw and was moving ahead slowly, when without the slightest warning, there was a terrific crash, a deafening noise, and a violent trembling of the steamer. Simultaneously with the crash, the first officer was raised in the air and knocked down flat on top of the pilot house. He arose instantly and looked aft. All he could see was clouds of steam, smoke and dirt, covering the entire after end of the ship.

"Upon discovering this condition the first officer rushed to the deck, calling to his men to try and rescue or help any who might be injured, but owing to the fact that the steamer had by this time caught fire, the crew could get no farther aft than No. 3 hatch.

"The city fire department had been summoned and within a short time extinguished the fire. When the smoke cleared away, the work of rescue was started and gave a view of the havoc created.

"It was discovered that the starboard boiler was blown clear out of the ship, having taken a forward and upward course, tearing out bulkheads, hatches, decks, deck beams, wrecking deck house and tearing off the starboard bridge and part of the upper works forward in its flight, and finally landed on the dock under a coal shed, a distance of about 300 ft.

"After landing on the dock, it was discovered that the boiler was turned upside down and end for end, having made a complete somersault, and a half circular turn, leaving the bottom of the boiler almost directly on the top and the front end pointing directly opposite to its original position.

"The entire after part of the steamer was found one mass of wreckage, consisting of broken, twisted, bent and splintered parts of what had been her cabins, boiler house, decks and smoke stack. The starboard side of the vessel, abreast of the after end of the boilers, was blown outward, leaving a gaping hole, extending from the spar deck down to within 2 ft. of the water line.

Port Boiler Knocked Off Saddles

"The port boiler was knocked off its saddles, dropped onto the boiler pans, rolled slightly to starboard, and stripped off all connections and fittings, save the main stop valve and safety valve on top, the main feed valve on the starboard side and the blow-off valve and water connection for water glass on the rear head.

"The work of rescue resulted in bringing forth four dead bodies from the ruins; the bodies being the remains of the chief engineer, assistant engineer, and two firemen, all frightfully mutilated and mangled. The oiler was blown into the river, from which he was rescued and taken to a hospital, where he died as a result of his injuries on June 12, 1913. One watchman was rescued from the wreckage of the deck house amidships, where he had been sleeping and rushed to the hospital, where he died on June 13, 1913. One of the firemen is still missing and it is supposed that he was either blown into the river or that his body is buried in the debris, thus making a death toll of seven men.

"Upon arriving on the scene of the disaster at 1:45 p. m., June 11, 1913, we immediately commenced our investigation. We first examined the ship and found her condition as already described. We then examined the exploded boiler that was on the dock. This examination showed the boiler resting as previously described. tube ends did not show any signs of burning and all the tubes were covered with a thin coat of scale which was not disturbed. Had the tubes been heated, this scale would have cracked off and the ends would show burn, but this did not exist. All parts of the combustion chamber that we saw did not show any signs of burning or low water. The furnaces also showed a normal condition. In view of the above conditions we are firmly of the belief that the explosion was not caused by low water.

"In the course of our investigation, we found the safety valve of the exploded boiler lying on the spar deck, just aft of the main cabin, at the extreme after end of the boat. From the surrounding conditions, it is very evident that this safety valve came down through the upper deck, and landed on its spindle on the spar deck, slightly bending the spindle. The valve was practically intact, save where it was broken off from the boiler and at its outlet.

Safety Valve Tested

"We took the safety valve off the port boiler and together with the one off the exploded boiler we had them carted to the boiler shop of S. Freeman & Sons Co., where, through the kindness and courtesy of their superintendent, Henry Wratten, we tested both safety valves. The result of these tests are as follows:

"Starboard safety valve, the one off the exploded boiler, leaked water slightly before any pressure was attained. At 60 pounds pressure, it leaked freely, and the valve lifted at 120 pounds pressure. We could not get over this pressure.

"The safety valve off the port boiler was then rigged up and pressure applied. This valve lifted and let go at exactly 150 pounds pressure, the steam pressure that the boilers were allowed.

"The fact that the safety valve off the wrecked boiler let go light, was due, we think, to its having landed heavily on its spindle, thereby springing the valve seat and easing the tension on the spring. The results of testing these valves compels us to believe that excess pressure did not cause the explosion.

The Cause of the Explosion

"We now come to that part of the boiler which leads us to believe was the direct cause of the explosion, and that is a defective part in the rear head of the boiler. In examining the wrecked boiler we noted that a piece of the flange of the rear head was still fast to the shell. This piece was directly on the bottom, and was 64 in. long, with irregular ends. Examination of this piece of flange showed that it was greatly deteriorated along the edge where it had been torn off the head. This deterioration existed just in the turn of the heel of the flange on the inside of the boiler, and was due to pitting and grooving. The head plate was ¾ in. thick, and where this defect existed some of the grooves or cracks extended down into the metal to a depth, in some places, of ½ in., leaving only ¼ in. of good material. This groove did not extend in one straight groove but ran the entire distance of 64 in. in three general grooves, with an average depth of ⅜ in. In some places the grooves were not so deep and in others they were deeper, and when it let go, the head gave way in the middle crown. After examining the piece of flange left on the head we then examined the lower half of the rear head which we found lying aboard the boat. There was a part of the flange missing on this head that corresponded identically with the piece that was left attached to the shell. The same condition as to pitting and grooving prevailed on this part of the head as it did on the piece attached to the shell.

"In examining the lower half of the head, we noted that all of the rivets that fastened it to the shell plates were sheared off, except those in the defective piece above mentioned. The rivets that fastened this part of the head to the shell were all in place, intact, and in good order. From this we deduce that this weakened part had reached its limit and burst, and in bursting it gained such momentum that it ripped out the whole back head, thus releasing the entire boiler pressure through this large opening, and creating this sad and terrible disaster.

"Our theory in this respect is borne out by the fact that all the interior parts of the boiler show that some terrific force drove them all aft, while the opposing force was expended in driving the boiler forward and out of the ship.

"In view of the above facts and the absence of any evidence of negligence on the part of the engineers, together with their previous good record and character, we herewith entirely exonerate them from any blame or responsibility for the accident.

"In rendering this decision, we do so because we are of the belief that the engineers did not know of the defect which existed. One reason for this belief is that the defect existed in such a place that owing to the in-
The front end showed the top part of the head caved inwardly about 12 in., leaving the tube ends projecting from 1 to 3 in., in all manner of shapes, some flattened, some bent and some twisted. The furnace fronts were off, grates out, and man and hand hole plates missing.

"Examination of the shell showed it to be intact, save indentations and bruises received in its flight. The shell was entirely stripped of all fittings, valves, etc. Upon careful and minute examination we could not discover any signs of rupture or undue strain in the shell plates or longitudinal seams. The longitudinal seams are double butt strapped, and triple riveted, with 1 1/16-in. rivets, pitch 3½ in. apart.

Entire Rear Head Blown Out

"Next we went to the back end of the boiler and here we found practically the entire rear head blown out. This head was originally put in convexly, the flange being entered into shell and fastened to the shell with a double row of 1 1/16-in. rivets, pitched 3½ in. apart, and staggered. Rows of rivets 2 in. apart. The head was put in in two pieces, with a double riveted seam across the center line of the head. (Rivets 1 1/16 in. and 3½-in. pitch.) The lower half of this was blown entirely away, and later found lying just back of the boiler's original position aboard the ship. The top half of the rear head was torn off about one-half the distance from center line of boiler to the top of the shell, and doubled back outwardly as one would turn a leaf in a book. The stay bolts that braced this rear head and the back sheets of the combustion chamber, pulled out of the combustion chamber sheets and remained in the head sheets. An examination of these stay bolts showed that they were 1⅛-in. bolts, outside diameter, and pitched 5 in. by 5½ in. apart. Some of the stay bolts that had been renewed at some time showed 1¼ in. outside diameter. A careful examination of these stay bolts failed to disclose that any of them had been broken previous to the explosion. All the rivets that fastened the head to the shell plates were sheared off, save for a few that still hold a piece of the head flange to the shell, around the bottom, and which will be taken up later in this report.

Blown to Pieces

"The boiler originally had two separate combustion chambers and two Adamson furnaces. Not an atom or single vestige of either combustion chamber remained in the boiler. Both combustion chambers were torn off from the furnace ends, leaving nothing where they had been, but the torn ends of the furnaces and broken, bent and twisted tube ends.

"The through braces over the top row of tubes were practically intact, save that they were all loosened up and pushed bodily backward. The staybolts from the side of the combustion chamber to the shells, were pulled out of the combustion chamber sheets and remained in the shell sheets.

"Upon returning to the steamer we first went into the combustion chamber of the port boiler, the one left in the ship. We examined this boiler for indications of low water, but could not find any. Both of the fusible plugs in this boiler were found to be in excellent condition. We removed both these fusible plugs and they are now in our possession. At the time we examined this port boiler, it was about half full of water and there was no sign of leaks anywhere. The tubes and tube ends, tube sheets, rivets, stays, etc., were all in good order. We could not discover any of the unusual indications that there had been low water.

"We next turned our attention to locating the fusible plugs that were in the exploded boiler, and looking for low water indications. Among the debris we located parts of a combustion chamber which we are inclined to think was the port combustion chamber of the exploded boiler. This piece of wreckage was twisted and bent almost beyond recognition. In this combustion chamber we found one

fusible plug. This plug was examined and found to be in excellent condition. The soft metal was soft and pliable. A slight scale had formed over the top which was not broken, and the manufacturer's name could be plainly seen. This plug is also now in our possession. We made a diligent search for the other fusible plug that was in the boiler, but up to date we cannot even locate that part of the boiler in which it was situated. It is our belief that this part of the boiler went through the side of the ship into the river, or is buried deeper in the debris and covered with coal. We will go to Racine from time to time as the work of clearing away the wreck progresses, and try to find this part of the boiler, and if found, will advise you in a supplementary report.

"We made a careful examination of the wrecked parts, and of the exploded boiler for signs of low water. The terior construction of the boiler, it was impossible for any one to get close enough to the rear head to examine it. In making an interior examination of the boiler, a man could go in the front and through a man hole, and go back only as far as the combustion chamber, 40 in. away from the rear head. The bottom sheets of the combustion chamber were only 6 in. from the shell, and instead of being braced with screw stays, they were braced with tee-irons, 3/8 in. thick, 5 in. on the base, and 3½ in. leaf, thus leaving a space of only about 2 in. to look through to the rear head. There was no hand hole in this rear head, so that a man could look and feel in there. Instead of hand holes, there were some 3-in. plug holes used for washouts presumably.

"In closing, we will say the boilers were built in 1888 by the Lake Erie Boiler Works Co., at Buffalo, N. Y. They were 11 ft. long and 132 in. in diameter; steel plate, 60,000 lbs. tensile test, and 0.846 in. thick, triple riveted and drilled holes. Last inspected April 25, 1913, at Racine, Wis., by members of this office.

"Examination shows the boilers have been repaired from time to time, and kept in good condition. At the present time they gave every indication of being in good condition, save where the defect existed in the rear head."

Fire on the Imperator

Fire broke out in the provision room of the giant liner Imperator shortly after she had tied up at her pier at Hoboken upon the completion of her second round trip on the Atlantic. All passengers had disembarked with the exception of her steerage, which were immediately marched to shore. For over an hour the fire was fought by the crew, utilizing the vessel's fire fighting equipment, and then a general call was sent in. The second officer lost his life by suffocation. The fire was confined to the provision room and the Imperator sailed on Saturday as per schedule.

Flooring for Ships

A New Composition Which Possesses Every Quality Ship Owners Have Been Seeking

SHIPBUILDERS and shipowners have for many years cast about for a composition flooring that would meet all the varied conditions to be found aboard ship. There are plenty of floorings, that are quite acceptable for stationary structures, such as hotels and apartment houses, but they are not at all satisfactory on board ship. The trouble with them all is that they are too hard and will crack under the strains and stresses to which a floating structure is subject, and, of course, the moment the floor cracks, moisture gets in. This problem of a satisfactory flooring has perplexed ship owners for a long time.

For this reason a special interest obtains in the new flooring, which has been put on the market by Byerley & Sons, 2484 West Fourth street, Cleveland, O. It has been tried out on board the passenger steamer City of Grand Rapids and the steamer Chemung, of the Erie Railroad Lake Line, and meets every condition that vessel owners have been seeking. It has, in fact, a great many merits for use aboard ship and new ones are being found every day. This composition has an asphalt base, into which stone pulverized to powder and other ingredients are mixed and the whole mass cooked for hours. It is applied boiling hot and forms a perfect bond with either wood, steel or concrete. One of the troubles with the usual composition flooring is that it will not bond with wood, but this composition, known as Byerlite, bonds so perfectly that there is no way of getting it off again except by chipping with chisel and hammer, and even then it is no easy task to get it off. The composition solidifies rapidly and has sufficient resiliency and sufficient powers of expansion and contraction to take up the vibrations of the ship and all inequalities of temperature. In fact, it is in no way affected by temperature, which is a very desirable thing aboard ship, for the temperature may vary from 100 degrees above Fahr. to 30 degrees below.

Being entirely mineral in character, it is indestructible. As neither heat nor cold nor fire nor water has any effect whatever upon it, it protects from erosion anything which it covers. Its greatest merit to the ship owner lies in the fact that it cannot be made to crack. There is no such thing as a crack in it, because it will yield a little to pressure and strain very much like an asphalt pavement. Moreover, it is possible to drive nails into it which it holds quite as tenaciously as wood, and therefore it is possible to fix furniture permanently to this flooring.

It is likely to find a field of wide usefulness as a protection to tank tops. The tank top of a modern bulk freighter is subjected to much punishment by the buckets of the unloading machines, especially the rigs operated by cables. Some vessel owners have covered the tank tops with concrete in order to minimize this damage, but concrete has not been found satisfactory for this service. Byerlite, lighter than concrete, makes an ideal covering as binding perfectly and yielding somewhat to pressure, it affords no hold whatever to the open blades of the bucket. There will undoubtedly be a wide demand for this product aboard ship as soon as its merits are understood.

Negotiations are being made by S. P. Wetherill, receiver for the Philadelphia & Gulf Steamship Co. for the sale of its two steamships Evelyn and Mae. The Mae is a steel steamer 243 ft. long, 42 ft. beam and 22 ft. deep. The Evelyn is an iron steamer 252 ft. long, 36 ft. beam and 24 ft. deep.

The address of Phillip J. Kroll, representative of the International Oxygen Co., in the Pittsburgh district, is Room 1023, Park building, Pittsburgh, Pa.

The San Francisco office of the Goldschmidt Thermit Co. is now located at 329-333 Folsom street.

Ships' Lifeboats

Report of the Boats and Davits Committee on Their Capacity and Stability

In their recent report the boats and davits committee of the British board of trade deal very fully with the investigations carried out by them in regard to the capacity and stability of lifeboats and rafts. In the case of open lifeboats five different types were considered, of which the chief dimensions and capacities are given in Table I.

The distinguishing characteristics of the boats are as follows:

Boat *A* is the fullest that has been proposed by the board of trade. The girths are in accordance with the requirements of the draft life-saving appliances rules.

Boat *B* has girths which comply with the requirements of the life-saving appliances rules which came into force on March 1.

Boat *C* has a 15-inch rise of floor, which gives a midship girth less than that required by the rules, but the quarter girths comply with the board of trade rules.

Boat *D* has the same midship section as boat *C*, but the quarter girths are only of sufficient fullness to give an equal internal capacity coefficient of .6. The form is the finest of all the types investigated.

Boat *E* was selected as being a design which diverged considerably from the rules. Its girths are less than those of any other boat which the committee could obtain.

The metacentric heights of the five boats under different conditions are given in Table II.

The freeboard, range of stability, maximum righting moment, and weight to be applied on the gunwale to heel the boat to the vanishing angle of stability have been determined for boats *A*, *B*, *C*, and *D* when laden with a number of persons ranging from 35 to 70, the results being recorded in Fig. 1. The committee have not investigated the extent to which the addition of ballast might alter the number of persons for which a lifeboat could be certified, but the curves of righting moments given in Fig. 1 throw considerable light upon the problem. It will be seen that additional numbers of persons beyond those shown in Table 1, would increase the stability

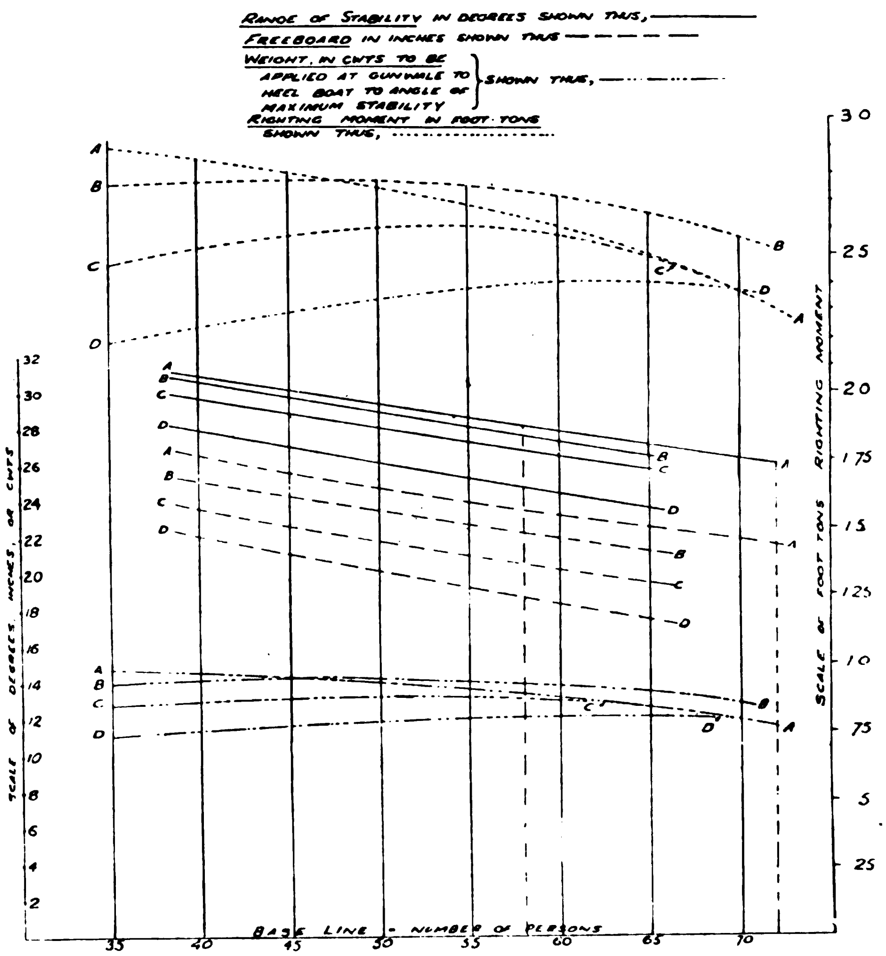


FIG. 1—FREEBOARD, RANGE OF STABILITY AND WEIGHT TO INCLINE A, B, C AND D BOATS

Table I.

Type of boat.	—Dimensions in ft.— Length.	Breadth.	Depth.	(½ Girth / (½ Breadth + Depth)) 100 — Measured to side of keel as per draft life saving appliances rules† — Amidships.	Quarter length from ends.	Measured to center of keel as per life saving appliances rules‡ — Amidships.	Quar. l'gth from ends.	Capacity in cu. ft. — L × B × D × .6	Stirling's rule	Actual co-efficient.	—No. of persons.— (L × B × D × .6) ÷ 10	Stirling's rule capacity ÷ 10	Stirling's rule capacity ÷ Girth numeral*	(L × B × D × .6) ÷ Girth numeral.*	Mean sheer in in.
A	28.00	8.5	3.5	90.0	80.0	91.5	81.5	500	577	.694	50	58	58	50	15.5
B	28.00	8.5	3.5	86.0	79.5	87.7	81.1	500	556	.667	50	56	56	50	15.5
C	28.00	8.5	3.5	81.3	78.2	83.0	79.7	500	540	.65	50	54	45	42	15.5
D	28.00	8.5	3.5	81.3	74.2	83.0	76.0	500	500	.60	50	50	42	42	15.5
E	26.62	8.17	3.33	86.2	73.7	87.5	75.0	435	438	.605	43	44	36	36	11.5

*The girth numeral is the divisor 10 or 12 laid down by General Rule 5, according as to whether the boat complies with prescribed girths and sheer, or not.

†By the draft rules the figures in the two columns should be 90 and 80 respectively.

‡By the present rules the figures in the two columns should be 88 and 80 respectively.

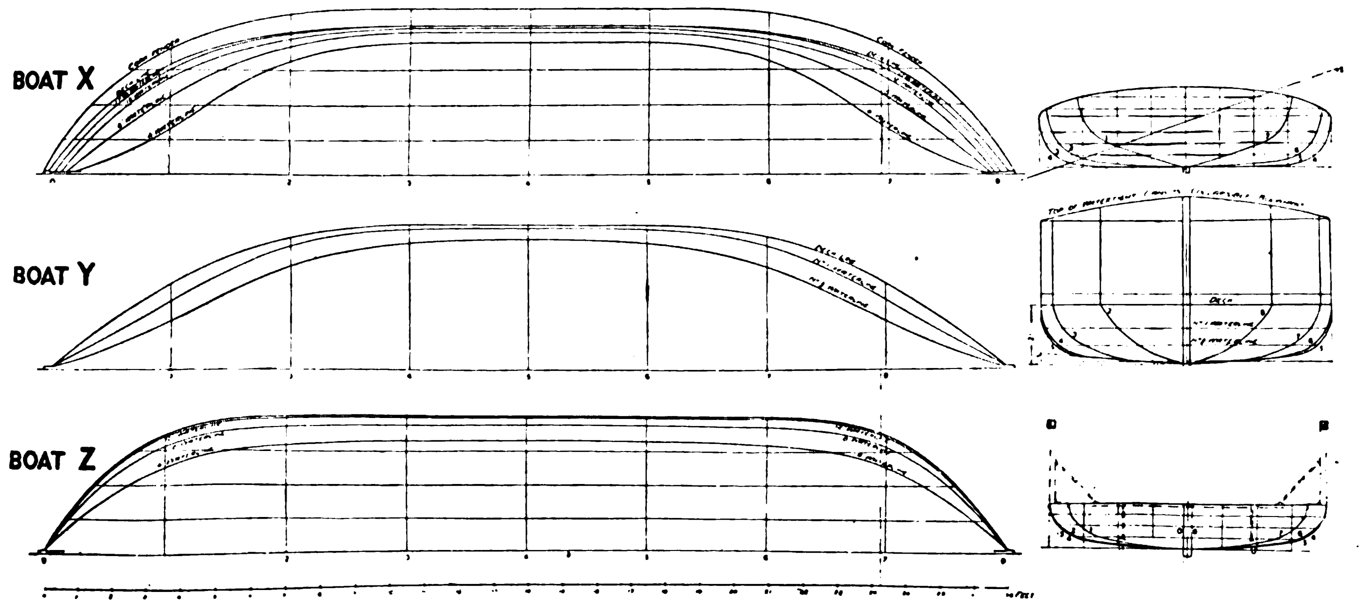


FIG. 2—LINES OF BOATS X, Y, AND Z

and therefore, if a weight equal to that of the additional persons were carried in the form of ballast, the stability could be increased. The committee are, however, of opinion that the use of ballast in a fully laden boat is not desirable.

Lifeboats *A*, *B* and *E* were tested for stability in a partially swamped condition. Water was allowed to enter through the drain holes until level with the water outside. *A* boat was found to have admitted 3.9 tons, *B* boat 4.03 tons, and *E* boat 3.83 tons of water. The drain-hole plugs were then inserted and weights were put on board having in each case the same weight and center of gravity as the complement of persons for which the boat would be certified under Stirling's rule with divisor 10. Some of the weights were then moved, one after another, to the gunwale to incline the boat. The relative figures obtained for the three boats in the partially swamped and unswamped conditions are given in Table III.

In all cases the center of gravity of the persons when sitting was assumed to be one foot above the top of the thwarts. In boats *A*, *B*, *C* and *D* the height of the midship thwarts was 2 ft. 7 in., and the end thwarts 2 ft. 10½ in. above the garboard strake. In the *E* boat the heights were 2 ft. 7½ in. and 2 ft. 9 in. respectively. In the case of open boats the center of gravity of the people proved to be the same whether they were sitting or standing.

Similar experiments were made in regard to two different types of decked lifeboats, *X* and *Y*, fitted with collapsible bulwarks, and a partially decked boat, *Z*, having a well in the center. Boat *X* had the interior filled with cork cuttings, while boat *Y* had cellular buoyancy air chambers. The dimensions of the three boats are given in Table IV, and their forms are shown in Fig. 2.

The results of the stability calculations are shown graphically in Fig. 3, and are summarized in Table V.

Experiments were made to check these calculations in a similar manner to that adopted with the open boats in the partially swamped condition. In the case of boats *X* and *Y* the water was allowed to flow freely through the ports in the canvas bulwarks while the boats were heeling over under the influence of the shifted weights. It should be observed that, when an open boat is inclined either by a fixed weight or by an external force, such as a sea, the angle of vanishing stability is that at which the gunwale becomes immersed; the moment of stability at that point is the upsetting moment. In a decked boat the angle of vanishing stability is the angle of maximum stability if the weight is fixed, but it is the angle at which the stability becomes zero if it is caused by a wave which passes away very quickly. These considerations are, of course, purely statical.

Table II.

Model.	Metacentric height in light condition. With equipment only. Ft.	Metacentric height in load condition. With 50 persons in each boat. Ft.	Metacentric height in load condition. With max'm number of persons allowed. Capacity (calculated by Stirling's rule) divided by 10. Ft.	Capacity (calculated by Stirling's rule) divided by Girth Numeral. Ft.
A	5.18	1.67	1.46 (with 58 persons).	1.46 (with 58 persons).
B	4.5	1.65	1.52 (with 56 persons).	1.52 (with 56 persons).
C	3.4	2.0	1.90 (with 54 persons).	2.1 (with 45 persons).
D	2.68	1.3	1.3 (with 50 persons).	1.47 (with 42 persons).
E	3.38	1.02 (with 44 persons only).	1.02 (with 44 persons).	1.26 (with 36 persons).

Table III.

	"A" boat. Un-swamped.	"A" boat. Partially swamped.*	"B" boat. Un-swamped.	"B" boat. Partially swamped.*	"E" boat. Un-swamped.	"E" boat. Partially swamped.*
Weight applied on gunwale to bring it to water's edge, cwts.	13.5	6	14	8.5	10.35	5.5
Degrees of heel when gunwale touched the water	28.5	16	28	14	26.5	11
Number of people	58	58	56	56	44	44
Righting lever in inches	5.4	1.5	5.9	2.0	5.0	1.6

*Note.—No allowance was made in the experiments on account of the buoyancy due to the persons in the boats.

Table IV.

Boat.	Length.	Breadth.	Height to top of deck.	Height to top of bulwarks when extended.
X	28 ft.	8 ft. 6 in.	1 ft. 5 in.	3 ft. 5 in.
Y	28 ft.	8 ft. 6 in.	1 ft. 9 in.	4 ft. 2 in.
Z	28 ft.	8 ft. 0 in.	1 ft. 4 in.	3 ft. 9 in.

With regard to the deductions to be drawn from the investigations which have been referred to in this article, the committee point out, in the first place, that Stirling's rule should be used in all cases to determine the capacity of open boats. This is clearly shown by Table I, from which it will be seen that the application of Stirling's rule gives, in the case of boats *A*, *B* and *C*, a capacity greater by 15.4 per cent, 11.2 per cent, and 8 per cent, respectively, than that obtained by the board of trade coefficient formula, differences of great practical importance where the total number of boats required is large. So far as form and proportions are concerned, the committee are of the opinion that the most valuable criterion of the fitness of a lifeboat to carry the intended number of people is its stability. In this respect the midship and quarter girth rules do not provide a true standard, as is shown by a comparison of the stability calculations of boats *C* and *A*; and it being undesirable that any unnecessary restriction be placed upon design, the committee recommended that the girth rules be not enforced.

In general, it appears that the stability of completely decked lifeboats can only be insured provided that the deck can be cleared of water almost instantaneously. Inasmuch as 2 cwts. placed on the gunwale of the decked lifeboat will submerge it, the difficulty of rapidly discharging the water through side ports becomes at once apparent. The decked lifeboat, which occupies as much deck area as the open boat *A*, is certified to carry 46 persons only, as compared with 58 persons in the case of the *A* boat. With 46 persons on board the maximum righting moment is about the same as that of the *A* boat with 58 persons on board; it increases steadily as the number of persons on board is increased, and does not attain a maximum even when loaded with 60 persons (see Fig. 3); but the range of stability, though nearly constant within these limits, is small. If the range of stability of the decked boat can be increased, there is no reason why the decked boat should not be certified to carry more people, as there is ample deck area. By adding permanent watertight bulwarks, placing buoyancy tanks along the sides in the angle between the deck and the bulwarks in order to increase the maximum righting moment, and providing means for rapidly discharging the water which breaks aboard, the committee consider an efficient type of life-saving appliance would be produced, and a decked lifeboat fitted with these suggested improvements should be allowed to carry an increased number of persons.

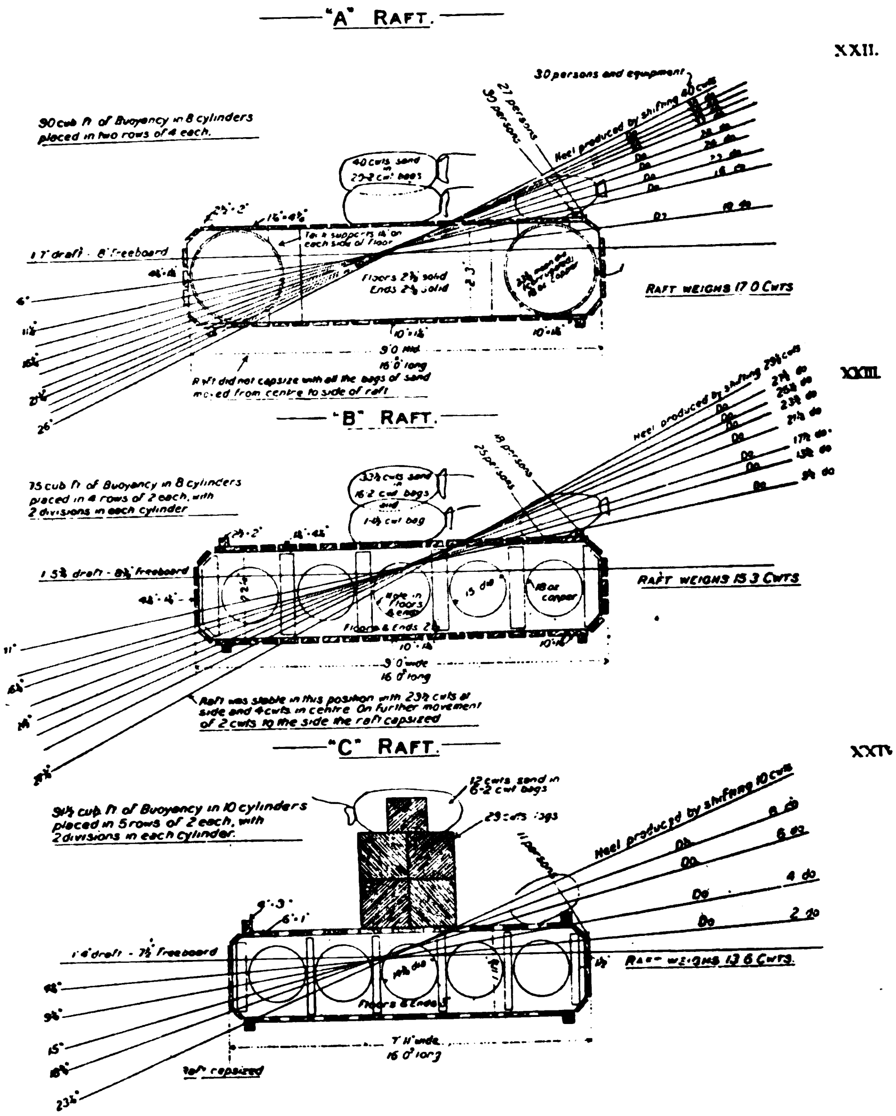


FIG. 4—STABILITY OF PONTOON RAFTS

The results of the committee's investigations relating to the stability of pontoon rafts are recorded in Figs. 4 and 5, and have proved that these pontoon rafts, if the buoyancy tanks are spread out as near the edges of the rafts as possible, can be given stability greater than that of an open or decked lifeboat. The rafts experimented with had dimensions 16 ft. by 9 ft. It is obvious that, by greatly increasing the length and correspondingly reducing the breadth, an unstable raft could be constructed, and therefore, if any considerable departure from the above dimensions is contemplated, the stability must be investigated.—This condensation is from *The Shipbuilder*, Newcastle-on-Tyne.

Table V.

	"X" boat.	"Y" boat.	"Z" boat unswamped).
Weight of boat without equipment (obtained from scales), cwts.	35	21.5	22
Number of persons in boat	46	46	49
Displacement coefficient (in loaded condition)	.693	.547	.645
Freeboard to deck of decked boat (in loaded condition), inches	4⅛	6¾	3⅝
Sheer on hull, inches	9½	None	None
Metacentric height in light condition with equipment, feet	9.3	8.16	10.5
Metacentric height in loaded condition, people sitting, feet	3.45	2.41	4.32
Metacentric height in loaded condition, people standing, feet	2.63	1.17	3.52
Maximum righting lever, i. e., at angle of greatest stability, in.	6.5	4.12	6.12
Weight applied at deck edge to bring decked boat to angle of greatest stability (i. e., weight to capsize boat, if weight remains fixed), cwts	14.8	8.2	12.1
Degrees of heel at angle of greatest stability which, in the decked boat, is the angle at which the boat capsizes if the weight remains fixed	19	13	8
Degrees of heel in decked boat at angle at which stability becomes zero	31½	27½	..

The new ore dock of the Northern Pacific Railway Co., Superior, Wis., received its first shipment of ore on Aug. 21. About one-fourth of the pockets are now ready, but the entire structure will not be completed for about a month. This dock handles ore from the Cuyuna range.

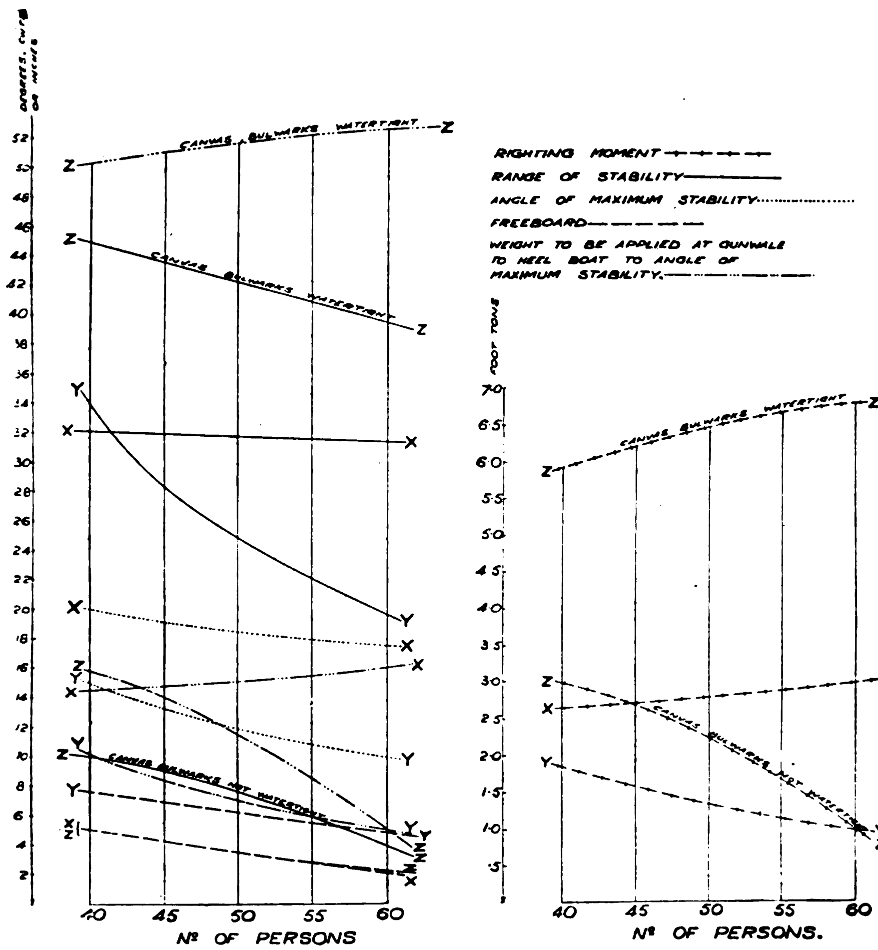


FIG. 3—COMPARISON OF STABILITY AND FREEBOARD X, Y AND Z

Will Not Call at Queenstown

The Cunard Steamship Co. has abandoned Queenstown as a port of call to pick up the mails on the westbound voyage insofar as its express steamers, the Lusitania and the Mauretania, are concerned. The matter has been made an issue by the postmaster general of Great Britain, who was not prepared to accede to the change and regards it as a departure from the terms of the company's contract dated July 30, 1903, which contemplates a call at Queenstown on the outward voyage. He holds that the suspension of this service will occasion considerable inconvenience to the people of Ireland. The postmaster general submitted the matter to the attention of the board of trade which is inclined to hold with the Cunard Co. The nautical adviser of the post office department himself held that it is not only hazardous in fine weather for the Lusitania and Mauretania to proceed into the harbor at any time near low water, but it is also almost impossible to select a billet in which they can swing clear of shallow water at single anchor. These difficulties would of course be greatly increased during a gale. On Feb. 23 last, the Mauretania entered Queenstown harbor about 1½ hours after high water, that is, on the ebb, and she anchored with her bow pointing up harbor. The strength of the gale prevailing was sufficient to overcome the influence of the tide and she was thus swung athwartship the harbor with her stern dangerously near the shoals. In this position she was practically fixed and could not use her screws for turning around to proceed to sea, but had to await the flood tide to swing her.

The Cunard Co. has omitted Queenstown as a port of call on the eastbound voyage of these two vessels since 1909, and it was this experience of the Mauretania that caused them to relinquish also the westbound call.

At a meeting of the board of directors of the Panama Railroad Co., and the Panama Railroad Steamship Line, recently held at Washington, it was voted to discontinue both services. The railroad charter dates back to 1849 and it was deemed an unwise policy to relinquish it. The net revenue of the operation of the railroad for the fiscal year ending June 30, 1912, was $1,997,280.80. The steamship line during the same period is credited with a deficit of $305,742.85.

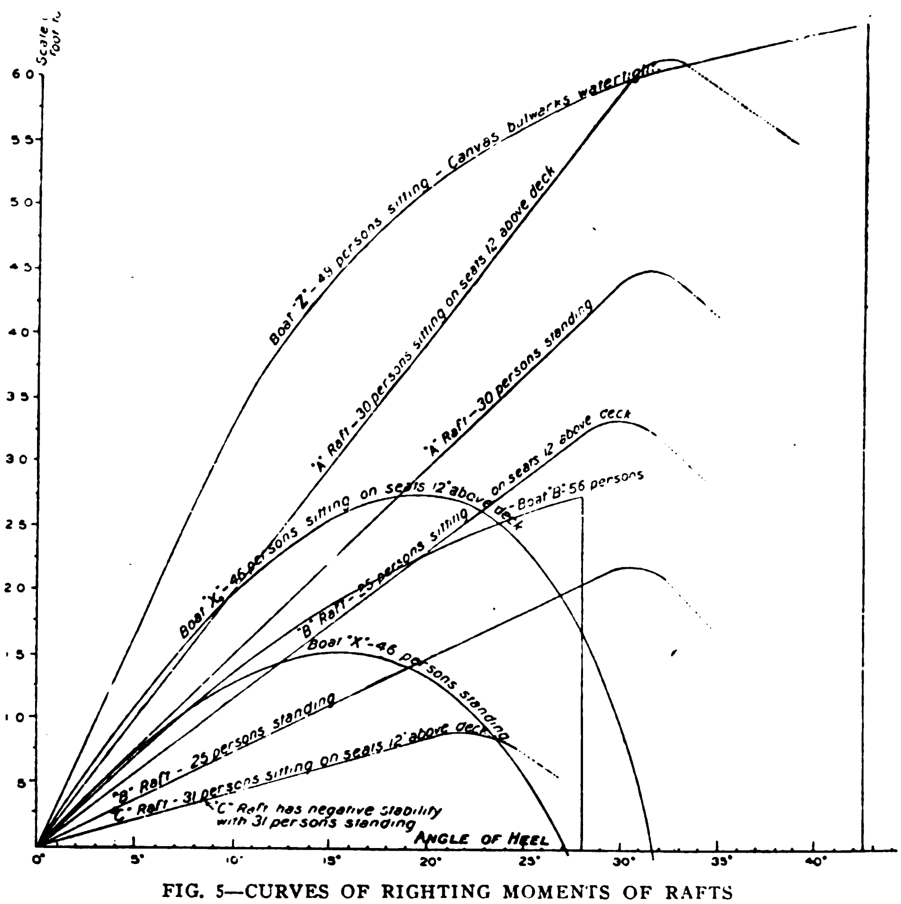


FIG. 5—CURVES OF RIGHTING MOMENTS OF RAFTS

THE MARINE REVIEW

DEVOTED TO MARINE ENGINEERING, SHIP BUILDING AND ALLIED INDUSTRIES

Published Monthly by

The Penton Publishing Company

Penton Building, Cleveland.

BOSTON	Room 510, 201 Devonshire St.
CHICAGO	1521-23 Lutton Blag.
CINCINNATI	503 Mercantile Library Bldg.
NEW YORK	503-4 West Street Bldg.
PITTSBURGH	2148-49 Oliver Bldg.
PHILADELPHIA	611 Bulletin Bldg.
WASHINGTON, D. C.	Hibbs Bldg.
BIRMINGHAM, ENG.	Prince Chamber.

Subscription, $2 delivered free anywhere in the world.
Single copies, 20 cents. Back numbers over three months, 50 cents.

Change of advertising copy must reach this office on or before the first of each month.

The Cleveland News Co. will supply the trade with THE MARINE REVIEW through the regular channels of the American News Co.

European Agents, The International News Company, Breams Building, Chancery Lane, London, E. C., England.

Entered at the Post Office at Cleveland, Ohio, as Second Class Matter.

September, 1913

The Panama Canal

"The design of Spanish adventurers in the fifteenth century is now being fulfilled by American engineers in the twentieth century. Columbus was the first to propose a water highway from Europe to Asia westward by way of the Atlantic. It was such a highway he sought, and not the New World, which he actually found. The pre-Columbian voyages and explorations of the Northerners had given Europe no knowledge of America, and, down to the time of the illustrious Genoese, Europe stood figuratively with its face toward Asia and with its back towards the Sea of Darkness, as the Atlantic in those days was called. So Columbus had no thought of finding a new continent, and no notion that one existed, nor is it reported did he ever realize that he *had* found one. The lands he discovered he regarded to the end of his life as merely some outlying islands or fringes of the Asian continent. *His* theory was that by crossing the Atlantic ocean he would come directly to the shores of China and Japan, for he clung to the old fallacy that whatever was *not* Europe or Africa *must* be Asia. Columbus, with the vaguest of ideas as to the extent of the globe, and with none but the faultiest charts, thought to find Cipango when he ran across Cuba, and died without knowing that he had added an enormous continent to the map. When, upon his last disastrous voyage, Columbus beat down the coast of Honduras to Darien, seeking a strait through the massive barrier that stayed his progress to the west, he little dreamed that at a point which he passed in his disheartening search a canal would one day separate two great continents and unite two vast oceans."

We have to look upon the old Spanish adventurers with considerable admiration. It was left to Balboa to discover the Pacific ocean. When he learned from the Indians that a great sea lay beyond the mountains that traversed the Isthmus, he lost no time in investigating the statement. With a small force of Spanish and Indian guides, Balboa succeeded in reaching the ocean, cutting his way through jungles and wading through swamps. By some happy chance he had crossed the Isthmus at its narrowest point. Afterwards he caused ships to be built to sail on this new ocean, and as there were no trees on the Pacific side they were built in sections on the Atlantic coast and transported across the Isthmus at a cost of over 2,000 lives. It was Charles V who ordered the first survey to be made in 1520 with a view to constructing a canal. Many explorers followed, including Lord Nelson, the hero of Trafalgar.

The first governmental act authorizing the construction of the canal appears to be that passed by the Spanish government in 1814. Revolutions were frequent, however, in this troubled quarter and nothing of a definite kind was done in the way of actual construction until the French undertook the task. Numerous surveys had been made by French, English and American engineers, involving no less than 19 different canal routes. The disaster that overtook the French with its terrible financial loss is common history. It is not necessary to enter here into the opera bouffe performance whereby the Province of Panama wrested her independence from the state of Colombo and became a republic, leasing a strip ten miles wide to the American government, through which the canal might be cut.

The preliminary work of construction began in 1904 and has been prosecuted with such vigor since that next month water is to be let into the Culebra Cut, completing the navigable channel, and as the last rivet was driven in the lock gates during the present month, it will be entirely practical to pass a ship from one ocean to the other forthwith, though such an event is not at present contemplated. Some ceremony will doubtless be made of the actual passing of the first vessel.

There is probably a disposition in the layman's mind to minimize the work that the French did on the canal, but there is no such disposition in the minds of the American engineers. They found that the French engineers had accumulated a vast amount of valuable data for them, not the least of which were actual figures on the water shed of the Isthmus over a long period of years. The mortality figures were also very important. At one time during the French regime the number of men employed was 10,854, and the mean yearly percentage of disease 62.50 per cent. At one time the death rate rose to

60 per cent. Obviously no work of magnitude could satisfactorily proceed when such a state of things existed. Curiously enough and quite naturally also the natives were immune, the disease attacking only aliens. The problem of sanitation was the first attacked and was attacked with such thoroughness that there are practically no mosquitoes or flies left on the Isthmus of Panama. There are a few malarial mosquitoes at Gatun, but there is not a single yellow fever breeding mosquito to be discovered anywhere. The work of sanitation was no easy task. Every house was covered with gauze netting; every pool of water drained; every receptacle that could possibly retain water, destroyed. Nothing could be thrown out of doors, not so much as an empty tin can, without being covered over, and all accumulations of this character were removed from every house twice a day. Every case of fever was traced to its origin and a film of oil spread over every gutter and open drain. Neither mosquitoes nor flies were given any chance to breed and those that were in existence were relentlessly pursued. It used to amuse the native to see a sanitary officer solemnly chasing a single mosquito, but the work has had its results. The Isthmus today is the sweetest place in the world in which to live from the standpoint of sanitation, and the death rate is lower than that of the leading American cities.

With the health of the workman guaranteed, the work of construction became a simple task. There were really no complex engineering problems to be met with in the construction of the canal. It has been simply a matter of ditch digging, an enormous one, to be sure, but nevertheless a ditch. More properly speaking, however, the Panama canal is really a water bridge, formed by damning the waters of the Chagres river at Gatun on the Atlantic side and Pedro Miguel on the Pacific side, forming an artificial lake, which floods 164 square miles of territory. Vessels are lifted from the Atlantic sea level section through three flights of locks into this lake, the lift being 85 ft. They are lowered through a similar flight of three locks to the Pacific sea level section. From this lake vessels may practically travel at full speed except through the nine miles of the Culebra cut, where the navigable channel is only about 300 ft. wide.

The canal will undoubtedly be open to commerce some time during the coming year. What its effect upon the shipping of the world will be remains to be seen. It will probably be many years before its commerce reaches the proportions of Suez, because the physical situation is so different. The Suez canal connects two great producing and consuming populations, Europe and India; the Panama canal simply connects two vast oceans. Its immediate development will probably be in northerly and southerly directions, that is to say, interchange of trade between the eastern portion of the United States and the western part of South America, and the western part of the United States with the eastern coast of South America, and obviously the interchange of commerce between the Atlantic and Pacific seaboards of the United States. Its effect upon merely domestic trade will undoubtedly be immediate, as there are vast quantities of freight now moving by the railways from the Atlantic to the Pacific seaboards that could be cheaper and better moved by ships. But when it comes to foreign trade, its effect is mere conjecture. Strategically, of course, the value of the canal is unquestionable.

The Armor Plate Bids

The secretary of the navy is tremendously stirred up over the fact that the three companies in the United States capable of turning out armor plate have put in identical bids for furnishing armor plate for the new battleship No. 39. He overlooks the fact, however, that the bids submitted are much lower than the sums that both England and Germany have to pay to their own steel makers. There has never been any real difference between the bids submitted for armor plate in the past and contracts have usually been split up among the three companies. Only the very largest of the steel-making concerns are capable of making any armor plate at all, as the initial investment is enormous. The secretary's proposal to have the government establish its own armor-making plant is a silly one. The government can buy all the armor plate it will need during the next century for far less money than it would take to establish such a plant. As long as the country has the assurance that it is getting armor as cheaply as any other nation, it ought to be satisfied. Steel makers will never grow rich over such a highly specialized product as armor plate.

Lake Trade

Notwithstanding certain drawbacks, such as strikes and thick weather, lake trade during the present year is phenomenal. A greater volume of freight is moving then has ever moved before and with comparative freedom from accident. The rules of navigation are being pretty scrupulously observed, and masters are evidently making the safety of their ships their first consideration. The year should be a prosperous one for the underwriters. The growing firmness of the iron market is reflecting itself in the trade, and the finish of the season will be brisk, shippers being determined to move all the ore that they possibly can. As reports indicate also a bountiful harvest, grain will make a heavy demand upon tonnage, and vessel capacity in the closing months will fetch a premium. As the rates are somewhat better than they were last year, and as the vessels are carrying considerable more per trip, the balance sheet ought to make a comfortable showing.

Loose Water in a Ship*

Experimental Determination of the Effect of Internal Loose Water Upon the Rolling of a Ship

By A. Cannon

BEFORE entering upon the subject of this paper, I shall ask you to allow me to outline briefly the sequence of events that led up to this experimental work, as it explains, in the clearest manner, the object of the study and its importance.

2. Professor Sir John H. Biles, in the opening remarks of his presidential address to the Engineering Section of the British Association in 1911, said: "During recent years accidents have happened to ships, and they have mysteriously disappeared. The complete disappearance without leaving any trace has led to the assumption that the vessel has capsized. The circumstances of such cases obviously preclude the existence of any direct evidence. The only subjects of investigation can be (1) the condition of the ship prior to the accident, and (2) the probability that such a condition could be one which in any known possible circumstances could lead to disaster. The first is determinable by evidence in any particular case. The second involves a consideration of the whole question of the behavior of ships at sea. What is the effect upon any given ship of a known series of waves? What waves is a ship likely to meet?

3. "This subject has occupied the attention of scientic engineers, and it may be said to have been considered a solved problem. We have thought that, if a ship has a certain metacentric height and a certain range of positive stability, she is quite safe from the action of a series of waves of any kind which we know to exist. If, however, a known ship (and perhaps more than one) has these safety-ensuring qualities and mysteriously disappears, it may be desirable to review the grounds of our belief, to see whether any known possible combination of circumstances may court disaster."

4. He then reviewed the whole subject of rolling of ships amongst waves and summarized his conclusions as follows:

"(1) With wave slopes of 3.6 degrees the angles of maximum roll obtained in the Revenge with bilge-keels may be taken as 22 degrees.

"(2) This roll takes place when synchronism exists between the wave and the ship, when the wave is 910 ft. long and 18½ ft. high and has a wave-slope of 3.6 degrees.

"(3) Waves exist which are of this length, but which may have a height of 50 ft., and possibly more, and a wave-slope of 10 degrees.

"(4) In such steeper waves we should expect to get much larger angles of roll.

"(5) Each ship has peculiarities of rolling due to its form, as well as to its lading and bilge-keels, etc.

"(6) These peculiarities and the effect they have upon rolling, and the effect different waves will have upon the rolling of the ship, can best be studied experimentally."

5. It had been the professor's intention, however, to have placed before the British Association the results of an experimental study of the subject, but, unfortunately, an accident incapacitated him for some time, and it was impossible for him to get the apparatus ready.

6. In December, 1911, I had the honor to be appointed by this institution to the new Post Graduate Research Scholarship in Naval Architecture, and Professor Sir John H. Biles suggested that I should take up the experimental study of the rolling of ships amongst waves, and he placed the machine that he had designed for this purpose at my

*Paper read before the Institution of Naval Architects.

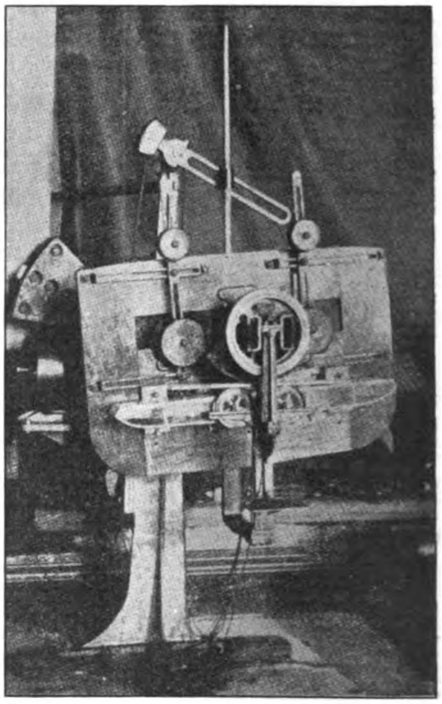


FIG. 4

Fig.2.

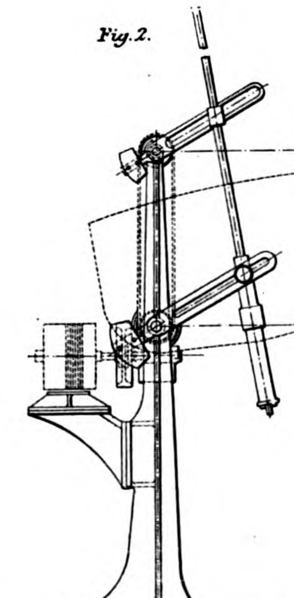
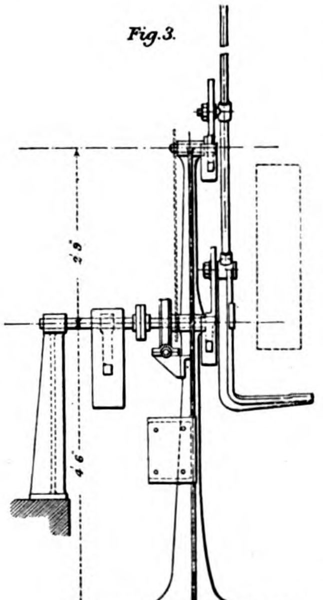
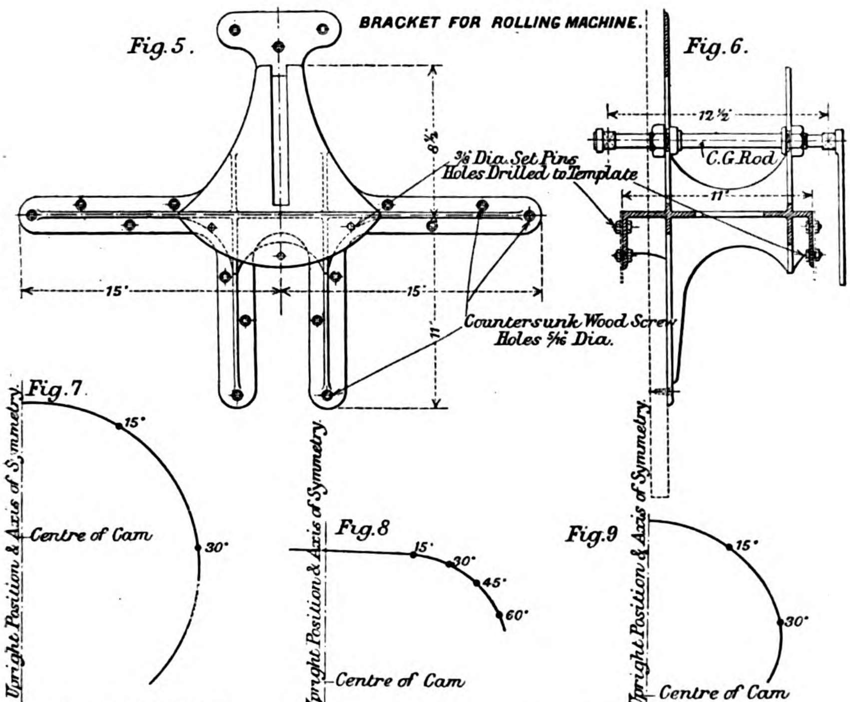


Fig.3.



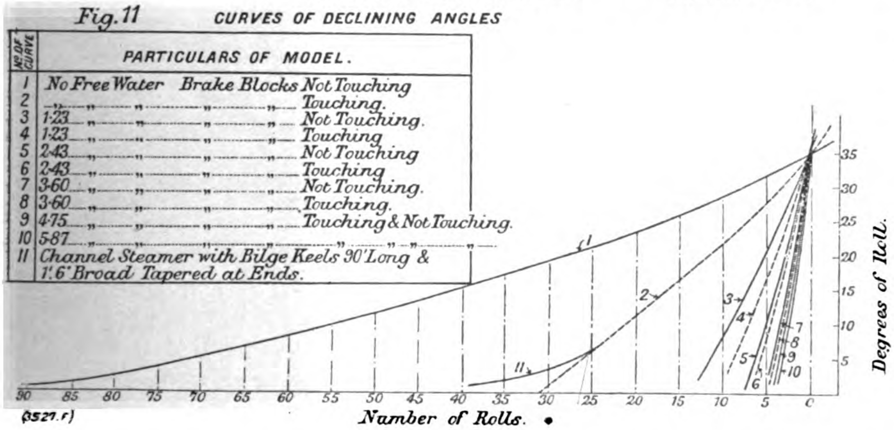


SHAPE OF CAM FOR CARGO BOAT 350'×45'×27' AT 22' DRAUGHT (3527.D.)

SHAPE OF CAM FOR EQUILATERAL TRIANGULAR PRISM, FLOATING WITH VERTEX DOWNWARDS AT 50% TOTAL DISPLACEMENT

SHAPE OF CAM FOR A RECTANGULAR PRISM OF BREADTH = TWICE DEPTH, AT 50% DISPLACEMENT.

Fig. 11 CURVES OF DECLINING ANGLES



No. of Curve	Particulars of Model.
1	No Free Water Brake Blocks Not Touching
2	" " " " Touching.
3	1.23 " " " " Not Touching.
4	1.23 " " " " Touching
5	2.43 " " " " Not Touching
6	2.43 " " " " Touching
7	3.60 " " " " Not Touching.
8	3.60 " " " " Touching.
9	4.75 " " " " Touching & Not Touching.
10	5.87 " " " " "
11	Channel Steamer with Bilge Keels 30' Long & 1'6" Broad Tapered at Ends.

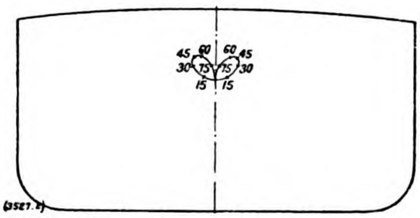
disposal. I accordingly submitted it as one part of a proposed scheme of research work, and the results of this study, so far as it has gone, constitute the subject of this paper.

7. Before entering upon this emperimental work, I investigated the statical effects of loose water in ships. This formed the subject of a paper that I had the honor of submitting to this institution last year. It was intended as a preliminary to the determination of the dynamical effects when rolling amongst waves.

8. The machine that has been used for these experiments is in many ways unique, and is the only one of its kind in existence in this country. The principles underlying its design were pointed out to this institution in 1900 by Colonel (then Captain) Russo, R. I. N., in his paper on the navipendulum; and also in 1902, when he gave the results of an experimental study of the rolling of ships amongst waves obtained by his apparatus. As, however, there are several new features in connection with the machine at Glasgow, it may be as well to give a brief description of it and the theory underlying its design.

9. A B and C D (Fig. 1.) are two radii that revolve about A and C re-

Fig. 10. LOCUS OF Z FOR CARGO BOAT 182'×27'×13'.5" AT 5'.9" DRAUGHT AND 600 TONS DISPLACEMENT KG-9.8 FEET.



spectively, and are always parallel to each other. A C is a vertical line. A rod E is pivoted at B to A B, and can slide through a sleeve D that is pivoted to C D. Then, if the values of r_1 and r_2 are correctly chosen, and A B and C D are revolved at a particular uniform speed, B will represent the orbit circle of a trochoidal wave of height $2r_1$ and B D will always lie in the direction of the normal to the wave slope at B. Thus the resultant force on any particle at B will, at this speed of rotation, always act along D B.

10. The lengths of r_1 and r_2 and the speed of rotation may be obtained as follows:

Let the machine represent a wave at a scale of $\frac{1}{n}$th the full size. Let l be the length of the actual wave and h its height. Then—

$$r_1=\frac{h}{2n}$$

$$\frac{R}{r_1}=\frac{R-d}{r_2}$$

or

$$R=\frac{r_1 d}{r_1-r_2}$$

and, therefore, if r_1, r_2 and d are fixed quantities, R is constant; that is, A C and B D always meet in the same point O. Thus, if we make r_2 of such a length that R is equal to the radius of the rolling circle of a trochoid of length l, and rotate the machine at the appropriate revolutions, B D will always represent the normal to the wave surface; as it is a property of the trochoidal wave that the line joining any point of its surface to a point vertically above its orbit center at a distance equal to the radius of the rolling circle is a normal to the surface at that point.

Now—

$$R=\frac{\quad}{2\pi n}$$

and—

$$r_2=r_1\left(1-\frac{d}{R}\right)$$

$$\therefore r_2=\frac{h}{2n}\left(1-\frac{2\pi nd}{l}\right)$$

The period of a wave length l is—

$$\sqrt{\frac{2\pi l}{g}},$$

and therefore the period of the machine will be—

$$\sqrt{\frac{2\pi l}{gn}}.$$

So that, in order to represent a wave of length l and height h, we make—

$$r_1=\frac{h}{2n},$$

$$r_2=\frac{h}{2n}\left(1-\frac{2\pi nd}{l}\right)$$

and rotate the machine at such a speed that its period is—

$$\sqrt{\frac{2\pi l}{gn}}.$$

11. The method of construction adopted for the machine can be seen in the detail drawings (Figs. 2 and 3), and in the general view (Fig. 4). The main frame is of cast iron. The radii A B and C D (Fig. 1) are formed of slotted steel levers, so that their lengths may be set to any values desired. The machine is driven by an electric D.-C. shunt-wound motor with a speed control in the armature circuit for the low speeds, and in the shunt circuit for the higher speeds. This is directly coupled to a worm driving a worm-wheel attached to the lower lever. The upper lever is driven from the lower one by means of a bicycle chain that passes over two equal chain wheels, one of which is fixed to each lever.

12. In order to secure uniform rotation and to prevent the machine from stopping too suddenly when the current is cut off, a heavy fly-wheel (see Fig. 2) is fixed between the motor and the worm. The speed of the machine can be varied from 15 to 40 revolutions per minute, and the control resistances are very sensitive indeed, so that any desired rate of revolution can be obtained within the above limits.

13. The machine was originally intended to be transportable, so that the various parts were made as light as was deemed advisable. It was found, however, that a good deal of vibration was set up in the vertical standard when the motor was running. To remedy this a stay was taken from the top of the standard to an adjacent wall. It was found that, owing to the great weight of the model—about 200 lb.—some means of balancing this was necessary to insure a uniform rotation. This necessitated making a continuation of the worm-wheel shaft and supporting its other end upon an independent bearing. The stay, fly-wheel, and counterbalance weight are shown in Figs. 2 to 4. The whole stands upon a wooden base that is fixed to a specially prepared concrete floor.

The Model

14. It is well known that if a cylinder be made whose section is of the form of the locus of the projection of the center of buoyancy of a ship upon a transverse plane as the ship is inclined, and the cylinder be so weighted that its center of gravity is in a similar position to that of the ship, then if this cylinder be placed upon a horizontal plane, the restoring couple at any inclination is directly proportional to the restoring couple acting upon the ship when at the same inclination. This principle has been made use of so often that it is unnecessary to demonstrate it here. It is also used in this case. Two steel plates are accurately made to the shape of the curve of buoyancy of the ship that it is desired to experiment upon, and the model is supported by them.

15. Colonel Russo supports his navipendulum upon curves that are involutes of the metacentric evolute and that are as near the center of gravity of the ship as possible. This, however, necessitates very short curves, and hence increases the mechanical difficulty of making them accurate. Also, his trochoidal path passes through a point near the center of gravity of the ship, whereas in this case it passes through the center of buoyancy. This is referred to again later (see paragraph 21).

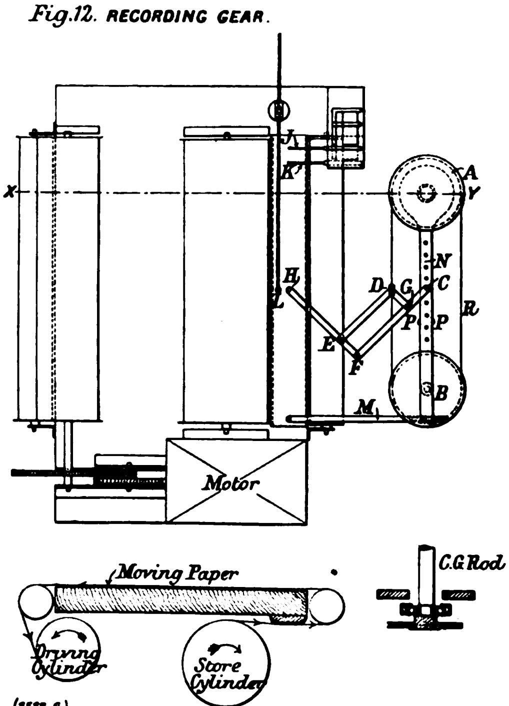
16. The model itself consists of a wooden framework made to the shape of a section of a ship. Attached to it is a heavy gun-metal casting, shown in Figs 5 and 6, to which the supporting plates are fixed. These plates rest upon two steel rods (afterwards referred to as the roller paths), each having a V-shaped groove in its upper surface. The bottom of this groove is made of semi-circular section, and the edges of the supporting plates are rounded, so that there is no rubbing between the sides of the grooves and the plates. Each roller path is supported upon two gun metal wheels (Fig. 4), mounted on ball bearings. These wheels are fitted to maintain the center of gravity of ship in the position it will occupy relatively to the wave surface if its displacement in the wave remains constant.

17. In order to obtain the correct rise and fall of G relative to the wave surface, these wheels should be cam-shaped. The shapes of the cams are difficult to determine. Some have been designed for various shaped vessels, and are shown in Figs. 7, 8, and 9 (annexed). A set was made for Fig. 7, but it was found that as the model rolled slipping took place between the cams and the roller paths. The wheels were then made circular. It was found that in some cases the cams would have re-entrant parts, which would preclude their use.

18. At the center of gravity of the model a steel rod passes from front to back (Fig. 6) through two slots in the gun-metal casting that carries the buoyancy plates. The position of this rod can be so adjusted that the center of gravity of the model is at its center line. Ball bearings are fitted to each end of the rod, and these pass through slotted guides, so that the only possible motion of the center of gravity is along a straight line. This line is parallel to the wave normal. When the machine is revolving at its correct speed, the force between these ball bearings and the sides of the slots will be negligible and will not interfere with the rolling.

19. In Colonel Russo's machine the curved supporting plates of his navipendulum rest upon a rigid base plate, so that the instantaneous axis of rotation of the pendulum is the line joining the points of contact of the supporting plates and the base plate. Thus the locus of instantaneous axes of rotation is the cylindrical surface

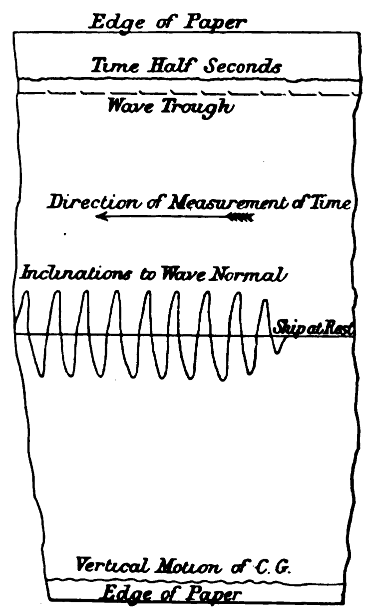
Fig.12. RECORDING GEAR.



SECTION AT X.Y.

Fig.13. SPECIMEN OF RECORD

VESSEL ON WAVE 30' HIGH, 900' LONG. WITH 1·23% FREE WATER.



formed by the plates, whereas in this case it is the locus of Z, where G Z is the righting lever at any inclination (Fig. 10, above). This is similar to the upper half of the curves given in the paper read before this institution in 1909 by A. W. Johns. He showed that the locus should be a double-looped curve, intersecting at a point near the C.G. In Colonel Russo's arrangement the axis might be some considerable distance from the C.G.

20. Double bottom tanks, etc., can be fixed to the wooden framework. By means of slotted bars, shown in Fig. 2, weights can be attached to the model and moved vertically to get the correct position of the center of gravity, and horizontally to obtain the correct moment of inertia about the center of gravity.

21. The whole is so mounted upon the rolling machine that, when the machine is in an upright position, corresponding to a wave crest or trough, the point of contact of the supporting buoyancy plates and the roller paths supporting them—*i. e.*, the center of buoyancy in the upright condition—is at the same level as the point B (Fig. 1). In this way the trochoidal wave produced is that which passes through the center of buoyancy in the upright position, or, in other words, it is the effective wave acting upon the ship. This will be very slightly flatter than the surface wave.

22. To obtain the correct C.G. of the model, the C.G. rod is set to its correct position relatively to the C.B. The model is then supported by small wooden blocks placed in the slots beneath the ball bearings on the C.G. rod, and the weights adjusted vertically until the whole balances at any inclination. In this way the C. G. can be set very accurately.

23. Having done this, the next step is to "wing" the weights until the correct moment of inertia of the model is obtained. The method adopted is to time the model for small angles of roll. Within the limits of isochronism the period of roll of a ship is given by—

$$\pi\sqrt{\frac{K^2}{gm}}$$

where K is the radius of gyration of the ship about a longitudinal axis through its C.G., m is the metacentric height and g the gravity acceleration. Now, K and m for the model depend upon the transverse scale of the model relatively to the ship, and are independent of the longitudinal scale. Calling the transverse scale $\frac{1}{n}$, as in the case of the rolling machine, we see that the period of roll of the model is equal to—

$$\pi\sqrt{\frac{K^2}{gmn}} \text{ or } \frac{1}{\sqrt{n}}$$

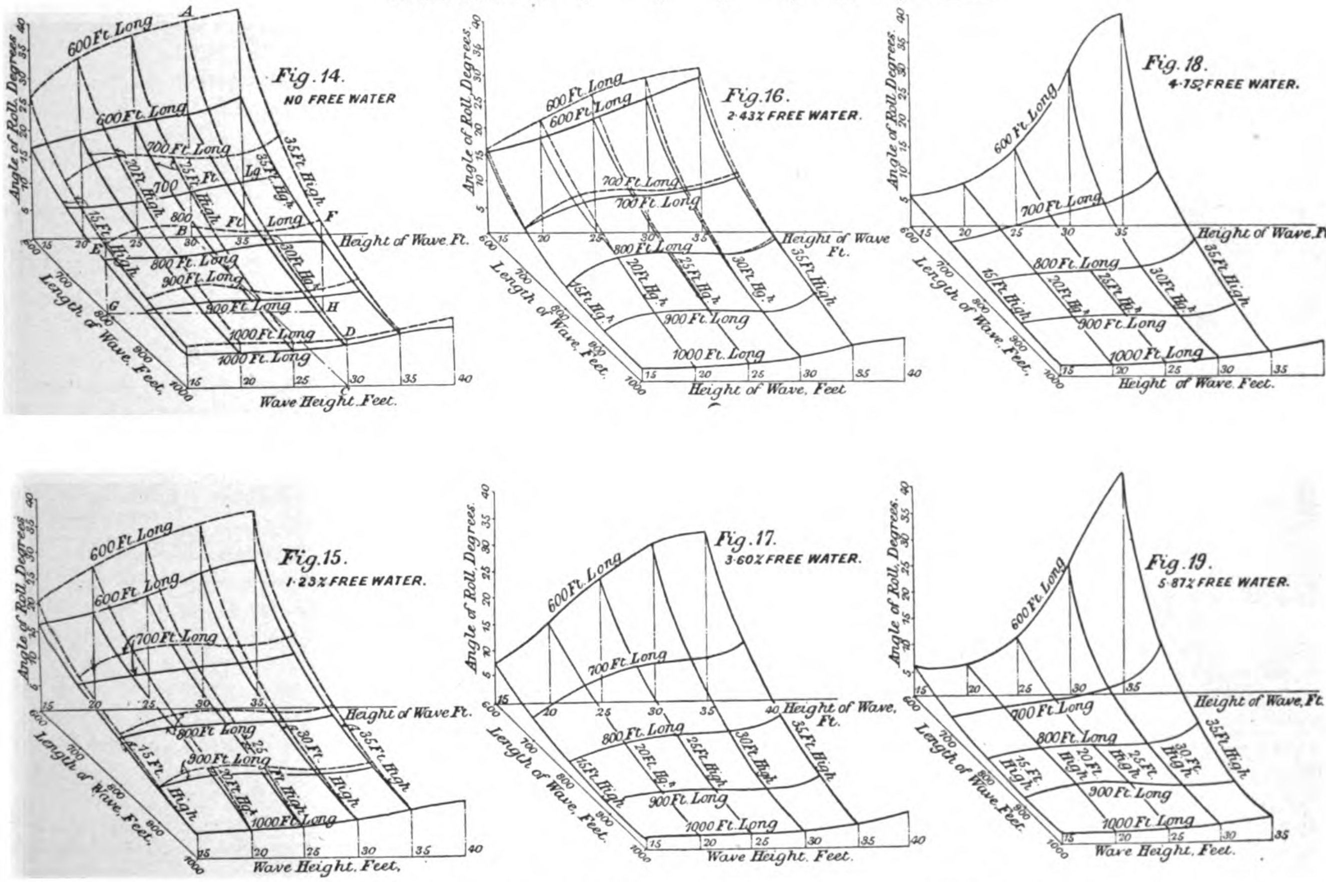
times that of a ship. The weights are then winged out or in until the period of roll at small angles is correct.

24. The choice of the value of n in any case is governed by many considerations. In the model the limits of B G in the upright condition are 5 in. and 12 in. The limiting length of G Z, the lever of stability, is 4¼ in. If it is greater than this, the point of contact of the buoyancy plate and its supporting roller path would fall outside the wheels supporting the path. The required lengths and heights of waves to be experimented upon also determine the value of n. The greatest and least wave heights are the limits to which the lower lever of the machine can be set; these are 24 in. and 4 in. respectively, and are equal to one-half the maximum and minimum wave height. The length r_2 of the top lever has been shown to depend upon the wave height, length, value of n, and also the length of Fig. 1. In the machine d is 33 in. and the limits of r_2 are 3.8 in. and 21.75 in.

25. Having fixed upon a suitable value of n subject to the above con-

ANGLES OF ROLL FROM NORMAL TO WAVE SURFACE, FOR VARYING WAVE HEIGHTS AND LENGTHS, AND VARYING PERCENTAGES OF FREE WATER IN DOUBLE BOTTOM.

Maximum Angles reached are indicated by dotted lines
Forced Oscillat.ns „ „ „ „ full „



siderations the shape of the buoyancy plates can be determined, and the size and shape of any double bottom tank, etc., with which it is desired to experiment, can also be determined and its position with respect to the C.B. In the case of a tank the longitudinal scale is of importance, as it may be desired to experiment with a tank of known length. This scale is fixed by the relation between the weight w of the model and W of the ship. Let this scale be x. Then $W = x n^3 w$. We know W, n, and w, so that x can be determined.

26. The researches of the late W. Froude led to the conclusion that the law of resistance to the rolling of a ship in still water at small angles was given by $d\theta = a\theta + b\theta^2$, where θ is the angle of roll from the vertical, and a and b are two cofficients that are constant for the same ship when under the same conditions of surface, displacement, and position of center of gravity, but are different for different ships.

27. From a consideration of the nature of the resistances to rolling that were likely to act upon a ship, he came to the conclusion that the a term in the equation for resistance was induced by a retarding couple, whose moment was proportional to the angular velocity, and the b term was induced by a retarding couple of moment proportional to the square of the angular velocity. It was therefore considered that, if it were possible to apply to the model resistance couples varying as the angular velocity and the square of the angular velocity, together with means of varying each, independently of one another, the whole field of resistance could be dealt with.

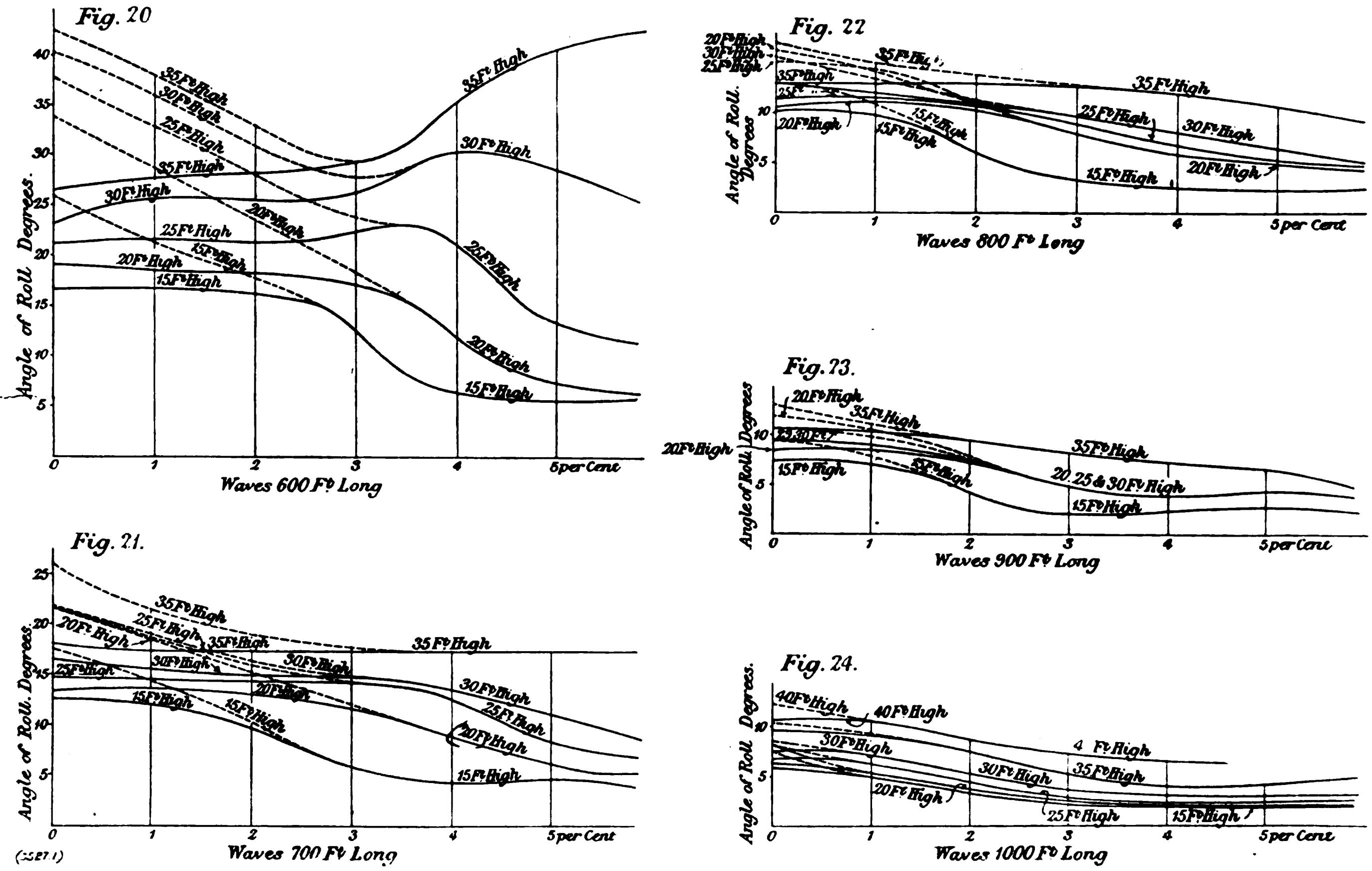
28. The first step, however, was to determine how much resistance was already acting as a result of pure mechanical friction and air resistance. At this time no suitable method had been devised of recording the angles of roll, so that the only means of determining the magnitude of the resistance was to heel the model to some known angle, and count the number of rolls before coming to rest. This was compared with all available data, and estimates were also made of the number of rolls that would be required under various resistances.

29. These experiments indicated that the mechanical friction of the machine was too great, and steps were taken to reduce this as far as possible. The wheels supporting the roller paths (Fig. 4) had originally plain bearings. These were made ball bearings. There was also a plain bearing at each end of the C.G. rod, where it passed through the guides (see paragraph 18). These were also altered to ball bearings. The grooves in the roller paths were considered to be too steep, and a new set of paths was made with a more open groove, and then the bottom of this groove was made semi-circular, and the edges of the buoyancy plates rounded, so that the contact was as near as possible along the edge (see paragraph 16).

30. In this way it was found possible to diminish the friction very materially, and, although it could not be totally eliminated, it was judged to be reduced beyond what would be the amount necessary. This was afterwards verified when a method was devised of recording the angles of roll (see paragraph 52).

31. The problem of arranging the necessary additional resistances in the manner desired has not yet been solved. Various methods have been suggested to accomplish this. These have been correct in theory, but could

CURVES OF ANGLES OF ROLL FROM NORMAL TO WAVE SURFACE.
Each curve is for a constant wave height and length and for varying quantities of loose water in double bottom expressed as a percentage of the total displacement.
Maximum angles reached are indicated by dotted lines ---------
Forced oscillations " " " " Full " ———



not be practically applied. The initial idea was to drive from the model a small dynamo having a constant field. This would induce a torque varying directly as the angular velocity. Part of the current so generated was then passed into an electric magnet of constant air gap, fitted with a circular armature that was oscillated by the model. In this way a torque would be induced that varied as the square of the angular velocity. By resistances in the two circuits the amount of each torque could be independently varied. An apparatus was designed to carry out these ideas, but it was found that the mechanical friction involved was too great, and also that the small currents generated at the dynamo were too weak to produce any magnetic effect. They were all lost in overcoming the internal resistance.

32. It is, of course, possible to have recourse to the device of Colonel Russo. He produces a resistance by causing a wooden pulley to rub against a stretched elastic belt. The shape of the pulley has to be determined for each case. So far, however, our efforts have been confined to arranging some means by which a variation of resistance can be easily accomplished. With respect to the experiments referred to in this paper, I am of the opinion that it is unnecessary to aim at any very faithful reproduction of the resistance. The reasons for this are stated later (see paragraph 52).

33. In addition to the problem of how to produce the resistance, there is the question of the amount that is necessary. Very little data are available respecting the resistance to rolling of actual ships, and practically the whole of this refers to warships. And of what is available there is such a difference in the values of a and b (paragraph 26) for the different vessels that it is impossible to say from this what the resistance would be for a merchant type. Owing to the courtesy of Sir Archibald Denny we were supplied with the results of tank experiments upon models of Channel steamers.

The Recording Gear

34. The problem of recording the angles of roll of the model was a difficult one, and attempts were made to solve it along various lines.

35. The chief difficulty is that there is no point on the model that is fixed. In other words, the axis of rotation changes from time to time. The nearest point to a fixed one is the C.G.

36. Colonel Russo uses the device of a third lever immediately beneath A B (Fig. 1), rotating parallel to it and of the same length. Then a rod joining the ends of the levers is always vertical. The recording gear is carried upon a table fixed to this rod, so that by means of a pen attached to the Navipendulum the angles of roll to the vertical are registered. The introduction of this third arm naturally makes the machine very high and much more massive. It is for this reason that it was not included in the Glasgow machine.

37. The method ultimately devised is that shown in Fig. 12. A gun-metal wheel A is fixed to the C.G. rod and oscillates with it. A steel lever N is attached to A by a ball bearing, and is constrained to pass between two guides P P, so that it always lies along the direction of the wave normal. At the end of this lever another wheel B is mounted, also on ball bearings. A cord R passes round these wheels. Then, as the model rolls, any point in R moves a distance proportional to the angle to the wave normal. This cord is attached to a small metal block D that forms one joint in a pantagraph as shown. The links CG, GD, and FG are equal, and FG is equal to DE, and FH to CF. Then the motion of H is an exact copy of that of D to a scale equal to $\frac{CD}{CH}$. The diameter of the wheels A and B and the length of the links have been so proportioned that the motion of H is 1/10 in. for every degree the wheels are turned.

38 A roll of paper is actuated by a small electric motor and cylinders as shown. The paper moves across a small metallic table, and the whole is mounted upon a wooden framework and attached to the rod E (Fig. 1) so that a pen attached to the pantagraph at H will move across the paper and produce a record of angle of roll relatively to the normal to the wave.

39. As the model rolls, the C.G. rises and falls, so that the record must be corrected for this. To enable this to be done, a rod M is attached and moves with it. At its end a pen is fixed which registers the rise and fall of the C.G. The pens J and K are attached to electro-magnets. One is connected to a clock, and registers half seconds, with a break at every ten seconds. The other is connected to a circuit that is automatically closed when the machine is at its lowest position, i. e., in the wave trough. From this the inclinations to the vertical can be found by adding the inclinations of the normal to the inclination of the model relatively to the normal. So far, however, it has not been possible to do this, as it is found that the point D has a certain amount of side play, no matter how tightly the cord is stretched. This is, of course, magnified in the record. It does not affect the angle registered, but alters its position relatively to the wave trough. Means are being devised to guide D so that it will always move along a straight line.

40. As the object of this study is primarily the safety of ships, the angle to the wave normal is the most important. A vessel that always moves with the wave, so that it is never inclined to the normal, may be said to be absolutely safe, although, perhaps, uncomfortable. The dangerous positions are those inclined to the wave surface, so that in investigating the question of the safety of ships at sea, we are really concerned with the rolling relatively to the wave normal.

41. Referring again to Fig. 12, a pen L is fixed, and draws a straight line that serves as a base line. A specimen of the record obtained is indicated in Fig. 13.

Experimental Results

42. As the only available information regarding resistance to rolling was a Channel steamer, it was considered best to experiment at first upon this type.

43. The dimensions of the vessel chosen for this purpose are 330 ft. by 42 ft. by 18 ft.; service draught, 11 ft. 9 in. molded; and displacement at this draught, 2,380 tons.

44. From considerations already outlined the scale chosen for the transverse ratio of the ship to the model was 13.5. With this ratio, the following are the particulars of the ship and model:—

	Ship. Ft.	Model. In.	Ratio of ship to model.
G. M.	2.8	2.49	13.5
B. M.	10.6	9.42	13.5
K. B.	6.80	6.04	13.5
Period of single roll, secs.	6.00	1.63	$\sqrt{13.5}$

45. The double-bottom tank used was one that had been designed for a different vessel, and is shown in Fig. 4. It is fitted with five division-plates, so that varying breadths of tank could be experimented upon. In these experiments only the two outer plates were kept in place, and water admitted into the space between them. The total transverse breadth of this is 32 in. in the model, or 36 ft. in the ship. Thus the compart-

ment stretches practically right across the ship.

46. The height of the compartment is rather large, being 4 in. at the center line and 3½ in. at the wings of the model. These correspond to 4 ft. 6 in. and 3 ft. 11¼ in. respectively in the ship.

47. The length of the compartment depends upon the longitudinal scale x (paragraph 25), which in turn depends upon the total weight of the model. The length of the model tank is 4¾ in.

Model Test on Waves

48. The model was tested upon waves of height equal to 15 ft., 20 ft., 25 ft., 30 ft., and 35 ft. For each height five different wave lengths were taken—viz., 600 ft., 700 ft., 800 ft., 900 ft. and 1,000 ft. One set of experiments was also carried out for a wave of 40 ft. height and 1,000 ft. long, but at this radius the machine was very difficult to balance, and there was a probability of overstraining it, so these experiments were not carried any farther.

49. With each wave length and height the model was tried in six different conditions. First with no free water, and then by five successive additions of water, each of 2½ lbs. weight. This alters the total weight of the model each time, and thus affects the value of the longitudinal scale x and, therefore, the length of the tank. Owing to the free water surface the positions of stable equilibrium are inclined to the vertical. The following table shows the particulars of the ship corresponding to these conditions:—

Weight of water in model. lb.	Wgt. of model. lb.	Per centage of total displacement as free water.	Length of compartment in ship. ft.	Inclination to vertical of stable equilibrium position. deg.
0	201.0	....	....	...
2½	203.5	1.23	57.0	3.1
5	206.0	2.43	56.3	4.4
7½	208.5	3.60	55.6	5.4
10	211.0	4.75	55.0	5.9
12½	213.5	5.87	54.4	6.1

50. In each case the center of gravity of the model was kept fixed by moving the balance weights. With free water the center of gravity is at the place it would be if the water were solid. Thus the effects produced are due merely to freedom of surface.

51. The method of procedure was as follows:—

The magnetic brake that had been originally designed to develop the resistance to the rolling was mounted in position as shown in Fig. 2, and was connected to an external circuit. When a current is sent through this the model is held rigidly and cannot roll. The machine is then started, and when the proper revolutions are reached the brake is released when the model is in the trough of a wave. It was found that the brake blocks still touched their circular armature and thus produced a certain retarding couple. Experiments were carried out to determine the amount of this, and in how far it affected the rolling, and also, at the same time, to determine the effect of internal free water in quenching rolling in still water.

52. Fig. 11 shows a series of curves of declining angles that were obtained with the brake blocks, first in contact and then absolutely free, each with different amounts of free water. On the same diagram is shown the curve from the experiments of Sir Archibald Denny. It will be seen from these that the resistance with the brake blocks touching is nearer the required amount than when they are free. Indeed, if the Denny curve were extended to large angles, it would probably be steeper than this. But apart from this question, as soon as a little free water is introduced into the model the resistance is enormously increased, and when the amount of water is from 4 to 5 per cent of the total displacement there is no appreciable difference between the curves of declining angles, whether the brakes are touching or not.

Simulate True Wave Motion

53. As before stated, when the arms are set to their correct lengths, the machine only simulates the true wave motion when rotating at the correct speed. In order to ascertain the speed, the time to do about 20 revolutions is counted and compared with the correct time. The speed is then altered to suit, and another record taken. The quantities required are the maximum angle reached and the amplitude of the forced oscillation. It was found that if several records were taken, as near around the correct period as possible, the results when plotted to a base of period of machine fall upon a regular curve, generally a straight line, and the values at the correct period can be obtained to a very fair degree of accuracy.

54. All the records were subjected to a system of cross-fairing, as shown in Figs. 14 to 19, inclusive. In these diagrams the values of the wave heights and lengths are set out in two directions at right angles to each other, in perspective, and the angles reached are set out perpendicularly to these. This enables one to see at a glance the effect of wave height and length. Thus a plane section like A B C D, in Fig. 14, shows the results for waves of the same height but of different lengths. While a section like E F G H shows the results for waves of the same length, but of different heights. With the longer waves of small heights, the oscillations were often of a double nature, a maximum and minimum occurring alternately. They were not very great, and to facilitate fairing the curves were drawn through the mean value. These oscillations are of no importance in affecting the safety of the ship.

Results Plotted

55. The results have also been plotted, as shown in Figs. 20 to 24. Each diagram is for waves of the same length, and each curve is for the same wave height, the abscissae being the amount of free water in the ship and the ordinates the angles reached.

56. Referring to Figs. 14 to 19, it will be noticed that, generally speaking, the shorter the wave and the greater the height, the larger is the angle reached. This is not always the case with respect to the wave height, especially with regard to the maximum angle reached, but it must be remembered that these angles are relative to the wave normal, and that, although this is smaller in some cases with an increase in height of wave, it is quite possible that the inclination to the vertical is not any less. This is borne out by the fact that the decrease of angle in any case is less than the increase of angle of the normal to the vertical, due to the increase of wave height. Another point to note is that the point of maximum angle to the normal is not necessarily one of maximum angle to the vertical.

57. Another notable fact is that, as water is admitted, the superiority of the maximum over the forced oscillation dies away, and at 3.60 per cent free water there is no difference. At this stage the ordinary cycles of roll no longer take place. The model rolls over to the angle of forced oscillation immediately, or else the roll gradually increases to a state of forced oscillation. In every case there was a very great effect noticeable upon these cycles, even with the smallest quantity of free water, indicating that a great deal of the energy was taken up in resisting the motion of the free water. Although, with internal free water, the positions of stable equilibrium in still water are

inclined to the vertical, the forced oscillations when amongst waves were generally found to be equally inclined to the wave normal and not to the equilibrium position. In the longer and flatter waves, however, there was a slight tendency to oscillate about an inclined position, which was very near to the wave normal and never so much inclined to it as the still-water equilibrium position. The total oscillation in these cases was always small. It is conceivable that in very long flat waves the oscillations may be about the equilibrium position, but in the shorter and steeper waves the internal water rushes across from side to side and the rolling takes place about the wave normal.

58. As the quantity of water increases, so the curves of angle roll for constant wave length get steeper for an increase of wave height. With 5.87 per cent of water on waves 600 ft. long and 35 ft. high, the motion was extremely violent; the water simply rushed in a foaming cascade from side to side, and the least disturbance only increased the effect.

59. Synchronism should take place at a wave length of about 750 ft., but it will be seen that the maximum angles reached will be for a much shorter wave. Upon timing the model, however, it was found that the period for an oscillation of 36 deg. was only 1.25 seconds, so that it is evident that the maximum angles are affected by the periods of roll for large angles, which one would expect to be the case.

60. Referring to Figs. 20 to 24, it will be seen that, generally speaking, the addition of free water decreases the angle roll. In the shortest and highest, and therefore steepest, waves, however, the effect is to increase the angle of roll, so that the forced oscillations are even greater than the maximum oscillations with no free water. This effect seems to be produced by the synchronism of the period rush of water across the vessel and the period of the wave. There will be a certain combination of wave length and height—*i. e.*, a certain wave steepness that will produce just the critical period for the water to rush across. When this takes place, the angle of roll may be very large. Further, these angles are reached in a very few rolls, and have been reached when starting from rest. It is, therefore, quite possible that dangerous angles may be reached in actual ships, where the vessel may have an initial heel and roll, although the resistance to roll may be very great.

61. On the other hand, if the quantity of water be limited, the angles reached are always smaller. This points to the efficacy of anti-rolling tanks having small water capacity for the safety of ships.

62. A great deal of work remains to be done on this very important subject. It is one of very great practical importance, especially in view of the growing tendency to adopt free water as a means of reducing rolling. It is proposed to carry out a similar series of experiments with anti-rolling tanks, with a view to finding out experimentally the actual effects of such tanks upon the maximum angles of roll. Till such work is systematically done, we cannot be sure that in all circumstances anti-rolling tanks will reduce rolling. It is hoped that this paper will stimulate interest in the subject.

Success of North American

The steamship North American, which was built by the Great Lakes Engineering Works for the Chicago, Duluth & Georgian Bay Line, of Chicago, has enjoyed a season far beyond the expectations of her promoters. The steamer has apparently sprung into instant popularity, as she has carried a full complement of passengers on each trip. The steamer carries no freight whatever, being devoted wholly to passengers. She makes a round trip each week to Lake Michigan, the Straits of Mackinaw, Georgian Bay and Lake Superior, and it is quite likely that the company will later on place an order for a duplicate.

Prof. E. E. Haskell, dean of the school of engineering, Cornell university; W. J. Stewart, chief geographer of the naval service department, Ottawa, and V. W. Forneret, superintending engineer of the St. Lawrence river ship canal, have been appointed a board to investigate and report to the minister of marine of the Dominion government on the whole question of water levels of the St. Lawrence at and below Montreal.

Col. William T. Rossell has been appointed chief of engineers, war department, vice Brig. Gen. William H. Bixby, retired.

SUMMARY OF NAVAL CONSTRUCTION.

Name and type of vessel.	Contractor.	Per cent of completion. Aug. 1, 1913. Total.	Aug. 1, 1913. Per cent on ship	July 1, 1913. Total.	July 1, 1913. Per cent on ship.
Battleships:—					
New York	New York Navy Yard	85.8	84.8	83.3	82.0
Texas	Newport News Ship Building Co.	91.7	90.6	90.6	89.4
Nevada	Fore River Ship Building Co.	40.3	20.1	37.1	17.2
Oklahoma	New York Ship Building Co.	37.7	27.4	33.0	22.7
Pennsylvania	Newport News Ship Building Co.	2.0	0.5	1.4	0.5
Destroyers:—					
Cassin	Bath Iron Works	99.3	99.3	94.4	94.4
Cummings	Bath Iron Works	90.4	90.3	88.7	88.6
Downes	New York Ship Building Co.	63.7	61.5	59.2	56.9
Duncan	Fore River Ship Building Co.	98.0	98.0	89.7	89.2
Aylwin	Wm. Cramp & Sons	96.9	96.2	94.3	93.8
Parker	Wm. Cramp & Sons	93.5	92.6	93.0	92.1
Benham	Wm. Cramp & Sons	92.3	91.6	91.4	90.8
Balch	Wm. Cramp & Sons	91.8	91.0	90.6	89.9
O'Brien	Wm. Cramp & Sons	7.1	1.4	6.2	1.2
Nicholson	Wm. Cramp & Sons	7.3	1.4	6.1	1.2
Winslow	Wm. Cramp & Sons	7.0	1.4	5.7	1.2
McDougal	Bath Iron Works	12.6	8.1	9.2	3.2
Cushing	Fore River Ship Building Co.	12.6	5.9	10.8	5.3
Ericsson	New York Ship Building Co.	9.6	3.0	7.9	2.8
Submarines:—					
G-4	American Laurenti Co. (Phila.)	93.4	92.5	92.0	91.1
G-2	Lake Tow Boat Co. (Bridgeport)	88.1	88.1	88.1	88.1
H-1	Electric Boat Co. (San Francisco)	94.5	94.5	94.5	94.5
H-2	Electric Boat Co. (San Francisco)	93.0	93.0	93.0	93.0
H-3	Electric Boat Co. (Seattle)	91.4	90.3	90.3	89.5
G-3	Lake Tow Boat Co. (Bridgeport)	69.6	69.2	68.8	68.1
K-1	Electric Boat Co. (Quincy)	85.9	84.0	80.7	78.7
K-2	Electric Boat Co. (Quincy)	85.0	83.0	80.5	78.3
K-3	Electric Boat Co. (San Francisco)	81.6	81.6	80.2	78.8
K-4	Electric Boat Co. (Seattle)	78.6	75.6	77.9	74.8
K-5	Electric Boat Co. (Quincy)	72.9	69.7	66.8	63.4
K-6	Electric Boat Co. (Quincy)	72.7	69.5	63.9	58.7
K-7	Electric Boat Co. (San Francisco)	71.9	70.2	68.0	66.2
K-8	Electric Boat Co. (San Francisco)	71.0	68.7	67.0	65.2
L-1	Electric Boat Co. (Quincy)	6.1	3.5	00.0	00.0
L-2	Electric Boat Co. (Quincy)	6.1	3.5	00.0	00.0
L-3	Electric Boat Co. (Quincy)	6.1	3.5	00.0	00.0
L-4	Electric Boat Co. (Quincy)	6.1	3.5	00.0	00.0
L-5	Lake Tow Boat Co. (Bridgeport)	00.0	00.0	00.0	00.0
L-6	Lake Tow Boat Co. (Long Beach, Cal.)	00.0	00.0	00.0	00.0
L-7	Lake Tow Boat Co. (Long Beach, Cal.)	00.0	00.0	00.0	00.0
M-1	Electric Boat Co. (Quincy)	5.5	2.9	00.0	00.0
Submarine Tenders:—					
Fulton	New London S. & E. B. Co. (Quincy).	14.3	5.8	13.4	5.5
Fuel Ships:—					
Proteus	Newport News Ship Building Co.	*	*	99.7	99.7
Nereus	Newport News Ship Building Co.	93.6	00.0	92.5	92.5
Jupiter	Mare Island Navy Yard	*	*	100.0	100.0
Kanawha	Mare Island Navy Yard	1.3	1.3	1.0	1.0
Maumee	Mare Island Navy Yard	1.3	1.3	00.0	00.0
Gun Boats:—					
Sacramento	Wm. Cramp & Sons	35.3	30.4	25.4	19.7
Monocacy	Mare Island Navy Yard	54.0	51.3	52.7	41.7
Palos	Mare Island Navy Yard	54.0	51.3	52.7	41.7

*Delivered at Norfolk, Va., July 5, 1913.

Isherwood System of Construction

Showing the Interior Framing Between the Tank Top and Spar Deck

By Robert Curr

THE profile with this article shows the interior framing between the tank top and spar deck. This plan shows the location of the transverses, bulkheads and longitudinals to advantage and by reference to the other plans there should be no trouble in getting out the work correctly.

The longitudinals as already explained run parallel with the sheer and shown with the same marks as on the other plans. Above the tank top are K to R. The longitudinals K and M are shown dotted.

In the bottom the longitudinals are run parallel to the center line, and a half breadth plan is necessary to show the bottom longitudinals to advantage. If the longitudinals were put in, in one length the midship section might be all that was necessary for the longitudinal plan but as they are longer than can be secured from the mill it is necessary to put them in two or three pieces; this, of course, does not matter seeing that the butt connection can be made as strong as at its weakest part, the fitting of the longitudinals in several pieces can be accomplished if care be taken in shifting the longitudinal butts clear of the butts of the strake of plating the longitudinal is on and the adjoining members.

The butts of any longitudinal or strake of plating should not be nearer each other than four feet.

The length of the fore peak does not exceed twelve feet so that it is an easy matter taking care of the longitudinal frames there.

The distance between the collision bulkhead and No. 20 is 108 ft., which would be a very long channel to order from the mill and at the same time an inconvenient length to handle in the punch shop. The arrangement of the butting of the longitudinals in this case will be probably an arrangement of three pieces for the longitudinals must not be butted in the same space and the shell plating butts must be considered, so that without the shell plating arrangement a definite shift of longitudinal butts cannot be accomplished.

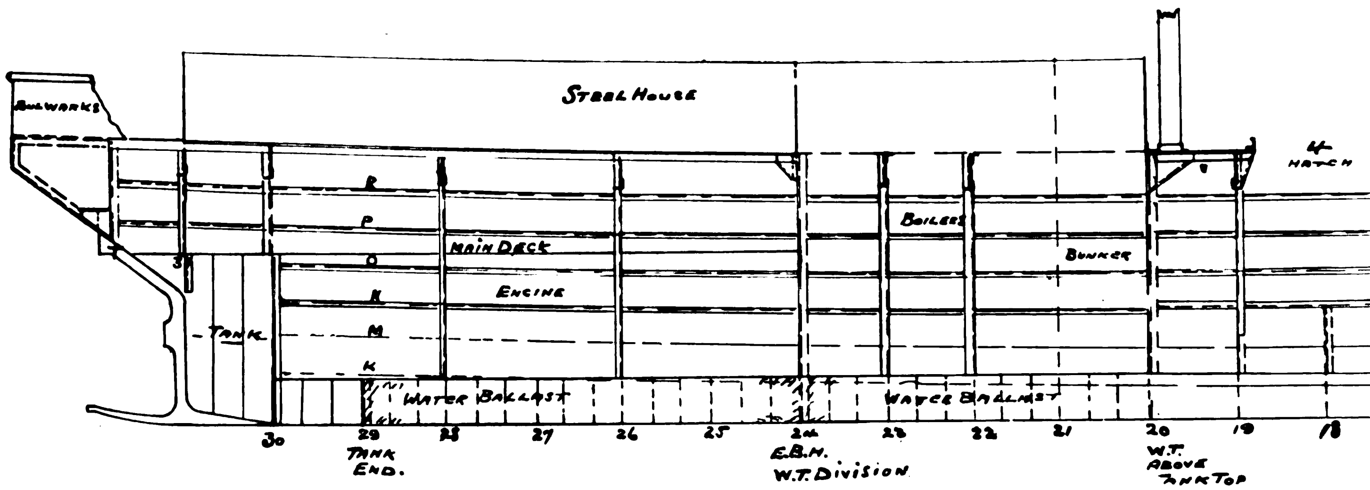
In the bottom between frames No. 2 and No. 12 the length is 60 ft., in that it will be a great advantage to use channels the full length of the fore or No. 1 tank. No. 2 ballast tank has a length of 72 ft. which extends from frame 12 to 24, even a long channel like this would be more economical than cutting same in two pieces. The length under the engine room being only 30 ft., this would make an easy arrangement for the one-piece channel.

The part above the tank taking in the coal bunkers and boiler rooms is only 24 ft. long, which makes the arrangement convenient. Abaft the boiler room the longest channel does not exceed 48 ft., which also saves the cutting of same.

The cross sections are made up of bulkheads and transverses Nos. 2, 12, 20, 21, 24, 29 and 30 being bulkheads and the balance transverses.

In the fore peak below K longitudinal the shape of the vessel makes it inconvenient and impractical to run out longitudinals below K and in this case extra frames are put in from the keel to K longitudinal.

Aft beyond the bunkers the frame spacing in the bottom is 2 ft., this apparently is necessary to take care of the engines and boilers and resist excessive buoyancy.



PROFILE SHOWING INTERIOR FRAMI

The transverses are on frames 1, 3, 4, 5, 7, 9, 11, 13, 15, 17 and 19 forward the top part across the deck forming an arch and compensating for the neglecting of stanchions in the hold, leaving a clear hold with no obstructions.

The transverses on the even numbers run only to the tank at side as shown at N. Abaft No. 20 in the boiler and engine space the tank top is 3 ft. at the center and drops 3 in. at the side dispensing with the hopper fitted forward in the cargo space. The transverses under the tank follow the tank top plating and on top the webs are fastened to same.

The transverses in the boiler and engine space are formed similar to the forward ones, only the connection to

---

This is the twelfth of a series of articles on the Isherwood system of construction which began in the September issue of THE MARINE REVIEW. The first article dealt with the general specifications of the steamer, the second with the sheer, half-breadth and body plans; the third explained the method of getting the sheer; the fourth dealt with the longitudinal and transverse framing; the fifth with offsets; the sixth with the shell plating; the seventh with the shell plating expansion; the eighth with the arrangement of plates and angles forming the spar deck; the ninth with the transverses; the tenth with bulkhead construction, and the eleventh with the connection of longitudinal frames to the bulkheads and transverses.

the tank top being flat instead of on a slant as in the hold.

The hatches are four in number and have an opening of 9 ft. fore and aft, leaving an overhang on the deck of 18 in., which is taken care of with bracket plates connecting the arches and deck together as shown on plan. By reference to the spar deck plan it will be seen that the longitudinal runs the length of the deck plating between the hatches in one piece, the arches being cut large enough for the angles to pass through.

By reference to the framing and bulkheads in the past articles this plan will be easily defined.

Miscellaneous Items

Secretary of the Navy Daniels has just returned from a three weeks' trip to the Pacific coast, where he visited the navy yards and naval stations.

It is understood that the two big vessels which Cramp's, Philadelphia, have been building for some time, are for the Spokane, Portland & Seattle railway.

Bids were opened on Sept. 2 by the lighthouse inspectors at Baltimore for the construction of a wooden lighthouse tender, to be 104 ft. 6 in. over all, 95 ft. keel, 22 ft. beam and 8 ft. 10 in. deep.

The Newport News Ship Building & Dry Dock Co., Newport News, Va., recently launched the Matsonia, building for the Matson Navigation Co., at San Francisco. The Matsonia is 501 ft. over all, 58 ft. molded beam, and 44 ft. molded depth.

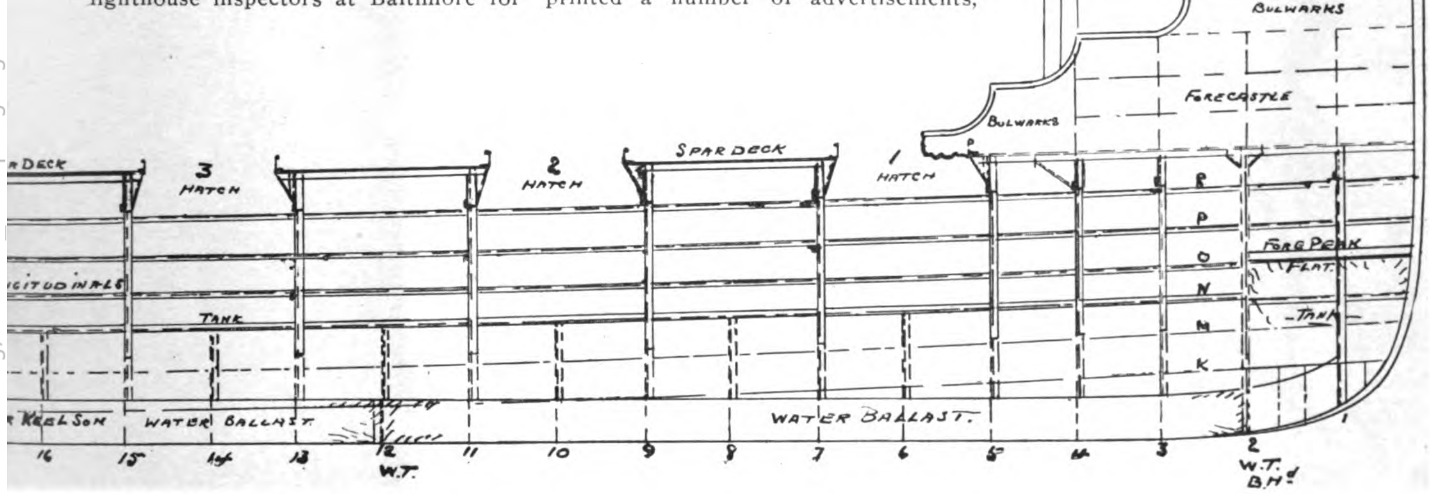
Secretary Daniels has authorized the construction of two large Diesel engines for the collier Maumee, at the New York navy yard, in Brooklyn. The Maumee is now being built at the Mare Island navy yard on the Pacific coast.

The Staten Island Ship Building Co., Staten Island, is building a tug to be known as the W. B. Keene for the Hilton-Dodge Lumber Co., Savannah, Ga. The tug will be 150 ft. long, 27½ ft. beam and 15 ft. deep, and will be used in the Atlantic coast towing trade.

The New York Ship Building Co., Camden, N. J., has been awarded contract by the navy department for the building of the destroyer tender Melville upon its bid of $1,310,000. The vessel is planned as a general repair and supply ship for a flotilla of 15 destroyers.

"All Famous" is the title of a rather unusual pamphlet being distributed by the Heine Safety Boiler Co., of St. Louis, Mo. This pamphlet derives its title from the fact that Heine boilers are in use by companies having trade marks which are well known. These trade marks are attractively arranged on the cover of the pamphlet, surrounding the trade mark of the Heine Safety Boiler Co. "Helios," the inference being that the merit of the various trade marks reflects upon the Heine trade mark. Within the pamphlet, there are reprinted a number of advertisements, each one referring to one of the well known trade marks, and stating the character and size of the boiler equipment in use by the company. The pamphlet also contains several advertisements on Heine Superheaters, pointing out important advantages of this type of superheater, such as close temperature regulation, the absence of necessity of flooding, the impossibility of danger from excessive superheat and so forth. Copies of this pamphlet will be found of interest and may be obtained upon application to the Heine Safety Boiler Co., of St. Louis, Mo.

The Chicago Pneumatic Tool Co.'s compressor department bulletin No. 34-L, just received from the press. This bulletin is one of the series covering our complete compressor line, and treats particularly of general engineering information of value to users of compressed air. It contains tables giving efficiencies of air compression at different altitudes, density of gases and vapors, mean effective pressures and horsepowers, loss of pressure due to friction in pipes, and many others, some rare and all important. Also information for intending purchasers, showing the data required for intelligent estimates. Views of various types of compressors are shown in miniature, as well as illustrations showing the interior of the Pneumatic Tool Co.'s compressor plant at Franklin, Pa. The bulletin is sent gratis to those interested, upon application to the Chicago Pneumatic Tool Co., Fisher building, Chicago, or No. 50 Church street, New York City, or any of its branches in all large cities.



WEEN THE TANK TOP AND SPAR DECK

Lake Erie Ore Receipts

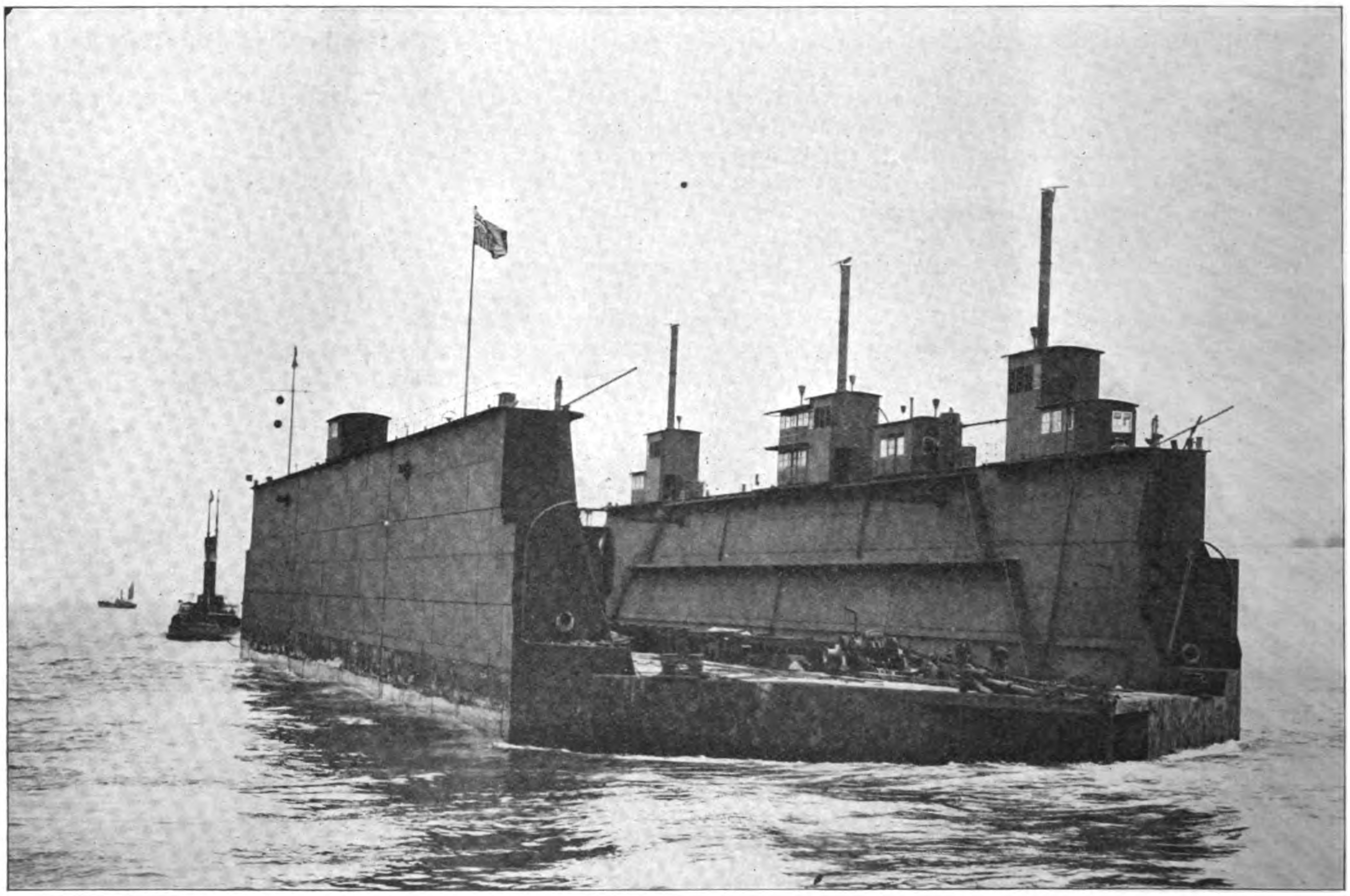
Out of a total shipment of 8,204,416 tons of ore on the great lakes during July, 6,600,875 tons went to Lake Erie ports distributed as follows:

Port.	July, 1913.
Buffalo	925,841
Erie	54,282
Conneaut	1,332,591
Ashtabula	1,384,425
Fairport	382,932
Cleveland	1,515,207
Lorain	672,327
Huron	131,648
Sandusky	....
Toledo	165,969
Detroit	35,653
Total	6,600,875

Large Floating Dry Dock

The large floating dock built by Swan, Hunter & Wigham Richardson, Ltd., and owned by the Societe Anonyme des Docks et Ateliers du Haut-Bosphore has safely arrived at its destination, namely, Stenia in the Upper Bosphorus. The dock is 490 ft. long, 95 ft. broad, and has a lifting capacity of 8,500 tons. It is of the bolted sectional type which combines the advantages of the great longitudinal strength of a box type of dock with facility for self docking. The dock in question has two side walls and has been built in three sections, each of which is really a complete box dock, *i. e.,* the walls are permanently joined with the bottom pontoon. When it is required to repair the under-water portions of the dock the three sections are disconnected and any two of them can lift the third section. There is an installation of powerful centrifugal steam pumps which can lift the dock with its maximum load in about four hours. The boilers for the pumping plant are placed in the house on the top deck of the starboard wall.

The dock was ready for delivery to its owners more than a year ago, but owing to the continuance of the war between Italy and Turkey a safe passage through the Mediterranean and Aegean seas could not be guaranteed. No sooner had the fight over Tripoli been settled when the outbreak of hostilities in the Balkan states was in full swing, which again caused the dock to be kept in the River Tyne awaiting more peaceful times. The towage was undertaken by two powerful tugs of L. Smit & Co., Rotterdam.



SELF-DOCKING FLOATING DOCK BEING TOWED FROM THE RIVER TYNE TO STENIA ON THE UPPER BOSPHORUS

Large Order for Valves

The Ross Valve Co., Troy, N. Y., has just been awarded the contract for making ninety-two resistance valves for the locks of the Isthmian canal. The contract was given after most careful examination by the Isthmian Canal Commission and its engineers, and a test of all valves suitable for the purpose, it being understood that the award was to be made strictly upon merit.

This is the largest order for valves of that character ever placed. The aggregate cost will be more than $30,000. The valves will be bronze.

The valves will be distributed as follows, and will be delivered at various times until Feb. 2, 1914: Twenty-eight at Gatun, 32 at Pedro Miguel and 32 at Miraflores. The pressure at which the first tests were made of the valves was gradually raised from 175 lbs. to 650 lbs per sq. in. While the valves are for use only in emergencies, they must be at all times ready for instant operation.

Safety chains are stretched across the canal locks at a point 90 ft. in front of the lock gates. Each of these chains will have four of the Ross resisting valves and hydraulic pressure will be so adjusted that if the ship should strike the chain the gradual relief from the impact will be so sure as well as steady that the biggest warship going at a speed of six miles an hour can be stopped before striking the gates.

The McClintic-Marshall Construction Co. has practically finished its contract on the lock gates on the Panama canal and the riveters and other steel workers are now leaving the Isthmus.

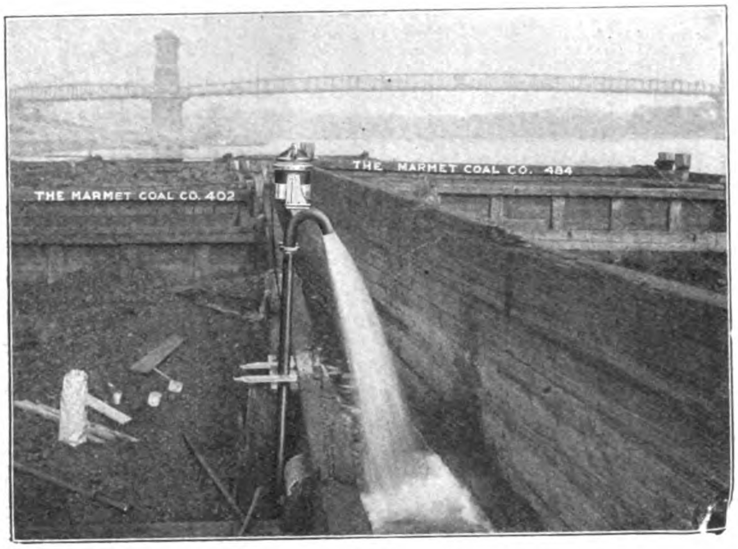
The two 500-ft. steamships building at the Cramp yard, Philadelphia, for the Spokane, Portland & Seattle Railway, will be equipped with Babcock & Wilcox boilers.

The C. Reiss Coal Co., Milwaukee, Wis., has given a contract to Heyl & Patterson, Pittsburgh, to install a 200-ton screening plant at Sheboygan.

Electro-Portable Pump

A portable electrically driven pump, with a capacity of 100 gallons per minute, is made by the Edwards Mfg. Co., of Cincinnati, O. The weight of the pump, including the motor, does not exceed 125 lbs. It is claimed by the makers that it will operate regularly up to its maximum capacity on current from an incandescent lamp socket.

The working parts of the Edwards Electro-Portable bilge pump are made of brass, operate on ball bearings, and are self-lubricating. There are no valves to take care of, and no possibility of freezing, the water automatically draining out as soon as the current is shut off. The motor is fitted to the exhaust tube, and sustains its own weight.



ELECTRO PORTABLE PUMP

It is claimed by the makers that this pump needs virtually no attention. There is no bearing on the shaft, and consequently no wear on the parts. It can be installed in working order instantly and is quite simple to operate.

Another electrically driven bilge pump is built by the Edwards Mfg. Co. for heavy work. This pump has a capacity of 500 gallons per minute. The construction is similar to that of the smaller pump. Two of these heavy duty pumps have been installed by the Louisville & Cincinnati Packet Co., and are said to be giving perfect satisfaction. Literature descriptive of these portable electrically-driven bilge pumps may be had by addressing the Edwards Mfg. Co., 320-340 East Fifth street, Cincinnati, O.

The Year's Shipbuilding

During the year ended June 30, 1913, there were built and officially numbered by the Bureau of Navigation, 1,648 vessels of 382,304 gross tons, compared with 1,720 of 243,792 for the same period of 1911, showing a gain of 138,512 tons and the largest construction since 1908. Of the 121 metal steam vessels 36 of 68,203 tons were built on the great lakes.

Ocean-Going Dredge

The steel ocean-going dredge Col. P. S. Michie was launched on Aug. 16 at Seattle, Wash., in the yards of her builders, The Seattle Construction & Dry Dock Co. The new vessel was christened by Eleanor M. Chittenden, daughter of Gen. H. M. Chittenden, president of the Seattle Port Commission.

The Col. P. S. Michie is a twin-screw vessel of great power. She is 244 ft. long, 43 ft. beam, 24 ft. deep, and is of the central well type. She will have a capacity of 1,000 cu. yds.

The Michie, when completed and equipped, will cost approximately $350,000. She is to be used at Coos Bay, Oregon, first to be used in government harbor improvement work. Her special work will be the deepening of harbors on the Pacific coast. The big dredge is to be built under the supervision of United States Naval Constructor G. C. Westerfieldt, who has represented Major J. J. Morrow, of the United States Engineering Corps.

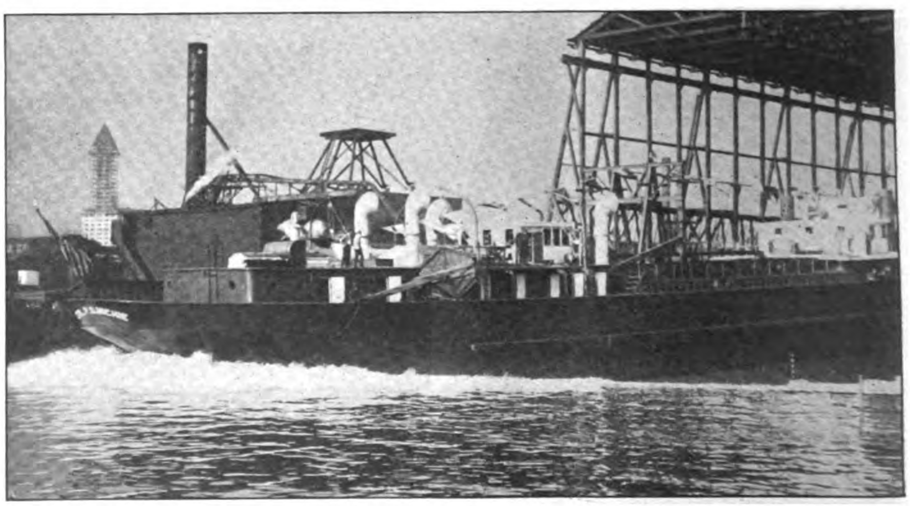
At the luncheon given after the launching by President J. V. Paterson, of the Seattle Construction & Dry Dock Co., Major Morrow, who was one of the speakers, explained that the Michie was christened in honor of Col. P. S. Michie, with whom nearly every officer now in regular service who graduated since 1863, was well acquainted.

Among those at the luncheon were Col. R. H. Wilson, commandant at Fort Lawton, and Gen. F. K. Ward, retired, who were classmates at West Point with Col. Michie.

The Bath Iron Works, Bath, Me., launched the torpedo boat destroyer Cummings Aug. 6. This vessel is 305 ft. 3 in. by 30½ by 17 ft. and of 1,020 tons normal displacement. The new craft was christened by Mrs. Henry Beates Jr., niece of the late Lieutenant Commander A. Boyd Cummings, for whom the vessel is named. The Cummings will burn oil exclusively and her fuel storage capacity amounts to 328 tons.

Cobb, Butler & Co., Rockland, Me., launched the hull of the new towboat Charles P. Greenough, Aug. 5, for the Commercial Towboat Co., of Boston. The new craft is 114 by 26½ by 15 ft. 11 in. The machinery will be installed at Portland.

John D. Sloane, supervising inspector of steamboats at Boston, has resigned.



LAUNCHING OCEAN-GOING DREDGE COL. P. S. MICHIE